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## THE PROGRESS OF CHEMICAL THEORY: ITS HELPS AND HINDRANCES.

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[*Introduction to the chemical course. A lecture delivered before the Franklin Institute, November 21, 1890.*]

[*Concluded from p. 334.*]

For example, in the phosphorus and arsenic salts only those which had like composition and like number of equivalents of water were isomorphic. Berzelius used both of these as guides but showed a preference for the dictum of his former scholar. In his later table of atomic weights of 1826, Berzelius corrected all but the alkali metals which he still considered united to oxygen in the proportion of 1 to 1.

It will be recalled that Sir Humphry Davy and his school had pronounced chemical inseparable from electrical activity.

He had shown that when a compound was decomposed by the electric current and the separate constituents collected at the opposite poles (as for example sulphur and copper) these substances when rubbed or electrically excited showed opposite kinds of electricity; the substance at the negative pole showing positive, and that at the positive pole negative electricity. If the separate constituents (such again as sulphur and copper) were heated, the heat increased their electrical tension up to the point where they combined, and then all electrical activity ceased, the opposite kinds neutralizing each other.

In conducting the current into the compound its constituents received again electric polarity and separated to the respective poles which attracted them.

Berzelius first stated his electro-chemical theory in 1812. His fundamental conception was that the atoms of bodies are electric and therefore have at least two poles which generally are different in strength, and following this difference the elements which these atoms compose are electro positive or electro-negative. This predominance of one kind of electricity extended to compounds, although necessarily more feeble in these. Compounds, according to this view, are the results of the attraction of the unlike poles of the atoms; and if in the compound there is a preponderance of one kind of electricity, this is because the atoms having this kind were more strongly polar than those having the other. Oxygen as the most electro-negative of all bodies was his criterion of the characters of the elements with which it combined. If the compound containing the least oxygen was basic then the body combining with oxygen was electro-positive. If the oxide were an acid then the element was electro-negative.

On this plan he arranged a table of elements in the order of their polarity. Of course, it followed that any body in this table was electro-positive to all the elements on one side of it and electro-negative to all those on the other.

His dualistic scheme followed as a matter of necessity, the two parts (whether two elements or acid and base) having opposite polarities. Thus:

$\overset{+}{Fe}\,\overset{-}{O}$ Ferrous oxide. $\quad \overset{+}{Ba}\,\overset{-}{O}$ Barium oxide $\quad \overset{+}{S}\,\overset{-}{O_3}$ Sulphuric acid. $\quad \overset{+}{C}\,\overset{-}{O_2}$ Carbonic acid.

or for salts.

$\overset{+}{Ba}\,O\,\overset{-}{S}\,O_3$ Baryta Sulphate. $\quad \overset{+}{Fe}\,O.\,\overset{--}{C}\,O_2$ Ferrous oxide Carbonate.

and in double salts.

$\overset{+}{K}O.\,SO_3$ Potash Sulphate. $\quad \overset{-}{Al_2}\,O_3.\,SO_3$ Alumina Sulphate.

Potasso aluminum Sulphate.

Berzelius carried his dualism and his electro-chemical theory into organic chemistry. In 1813 he had discovered a simple relation between the elements composing the organic acid and the oxygen of the base, and had proved the combination in multiple proportions in organic chemistry, and it was he who recommended the study of organic bodies in their combinations with inorganic.

He supposed organic, like inorganic, bodies to be binary in constitution, but with compound radicles instead of simple elements. This was Lavoisier's idea. Gay-Lussac had characterized alcohol as consisting of ethylene and water; sugar as carbon and water. Döbereiner called oxalic acid a compound of carbonic acid and carbonic oxide. Berzelius opposed this conception as inconsistent with his electro-chemical theory. He could not acknowledge the existence of oxygen radicles. Yet the probability of such radicles was rendered strong by the discovery of organic bodies containing the same numbers of the same elements, yet exhibiting very different properties. This could only be explained by supposing that the proximate constituents were different.

Wöhler, Liebig and Berzelius, after much hesitation, accepted the fact above referred to and the latter designated the phenomenon as one of isomerism. Liebig and Wöhler had shown that a constituent of the oil of bitter almonds remained unchanged throughout a number of reactions, and

this compound, of which the composition was $C_{14}H_{10}O_2$, they called benzoyl. (It is now called dibenzoyl or benzil.)

At first Berzelius was disposed to accept this as an organic compound radicle,* but reflecting that it must play the electro-positive *rôle*, although containing oxygen, he finally rejected this hypothesis which he deemed inconsistent with his electro-chemical and dualistic theory; and he was led to the assumption of arbitrary radicles containing no oxygen, of which the formulas, when written together, completely obscured the intimate relationships which existed between classes of salts. This was Berzelius' first fault, not so much due to his vanity, as to the feeling which was well founded that the scheme he had with such infinite pains established was right; that it was being destroyed on theoretical grounds which, although he could not then satisfactorily answer them, with the instinct of a great genius, he felt to be wrong. But his attempts to evade the conclusions only led him into self-contradictions which, when exposed produced the same effect upon the chemical mind that the reported insolvency of a great banking house produces on the financial world. The failure of a Berzelius shut up the current coin of theorizing the world over.

Berzelius believed that the radicles were unchangeable. Liebig and Dumas were not convinced of their entire unchangeability. The two sets of views separated more and more. Liebig finally defined a radicle as one which must be—(1) an unchangeable unit in a number of compounds. (2) It must be replaceable in these by simple bodies. (3) It must allow the simple bodies with which it is combined to be replaced by others, to form with it new compounds. This was the old radicle theory.

In 1827, J. B. Dumas (1800–1884) commenced a series of researches on the vapor densities of many substances which are solid or liquid at ordinary temperatures, and showed that if Gay-Lussac's law of the identity of atom-weight with gas-volume-weight be true, then some of Berzelius' atom-weights were double and some were half what they should be. This cast doubt on the truth of the law as well as on

* Spelled also *radical—radicle* is used by Watts.

Berzelius' work, but the latter held fast to his numbers (which were right), and simply confined his employment of the volume theory to permanent gases. The effect upon the minds of chemists, however, was disastrous; for even Gay-Lussac, Liebig and others, despaired of getting any information as to the atoms, and fell back on the equivalents which were shortly afterwards more precisely defined by Faraday as the contemporaneous quantities of the various constituents of compounds which an electric current of given intensity would disengage. This he called the law of constant elec trolytic action.

Under the unfortunate fear of having been misled, all attempts at theory were suspended. Gmelin in the colossal work which bears his name went back to the apparent weights of combination of Lavoisier's time, and the soul was taken out of the science. But Dumas dealt Berzelius a heavier blow still in the field of organic chemistry in his substitution theory, which he called "metalepsie," of which the two propositions were:

(1) If a hydrogen compound is subjected to the action of chlorine, iodine or bromine, it takes for every atom of hydrogen lost an atom of one of these elements to replace it.

(2) If the body contain water, it loses this without replacement.

Auguste Laurent (1807–1853) went further and asserted that the congeries of atoms called radicles which had suffered this substitution of H by Cl, or the loss of water remained practically the same in properties. This was called the nucleal theory which was short-lived, but before it had quite disappeared from the field Dumas came forward with his discovery of chloracetic acid, and declared himself for Laurent.

He maintained that the newly-formed body in such substitutions must resemble the old and he classed such original and substituted products together as derivable from the same type. This is called the old-type theory to distinguish it from the new-type theory subsequently set up by Laurent and Gerhard. Dumas showed that his trichloracetic acid in spite of the substitution of six atoms of chlorine for

six atoms of hydrogen was similar in its behavior and characteristics. He stated that "In organic chemistry there are certain types which remain constant even when one substitutes an equal volume of Cl, I, and Br for their H." Acetic and trichloracetic acid, aldehyde and chloral, marsh gas and chloroform, belong to the same chemical type. He went so far as to assert that all bodies derived from each other by equivalent substitutions belonged to the same "mechanical type." This was followed by the following declaration of war against Berzelius' dualistic theory. "Every chemical compound forms a complete whole, and does not consist of two parts. Its chemical character depends principally upon the number and arrangement of its atoms, and secondarily upon their chemical nature."

Berzelius was obliged to account for the facts discovered and to conform his explanation to the new discovery of Melsens in 1842, that chloracetic acid was reduced to acetic acid by potassium amalgam. He finally decided to do this by supposing that

$$C_2(H_2)_3 + C_2O_3 \cdot H_2O = \text{Acetic acid.}$$
$$C_2(Cl_2)_3 + C_2O_3 \cdot H_2O = \text{Chloracetic acid.}$$

In other words that acetic acid consisted of a radicle ($C_2H_6$), and trichloracetic acid of the corresponding radicle ($C_2Cl_6$), each respectively paired with oxalic acid ($C_2O_3 \cdot H_2O$).

But in doing this he gave up the very principle that he had been contending for, viz: that the radicles were unalterable: since it was evident that in the first two symbols of the formulas a radicle $C_2H_6$ had been changed by substitution into $C_2Cl_6$.

This admission weakened the faith of his most admiring followers and threw the blight of timidity over the speculations of chemists for thirty years. And yet withal, Berzelius was right in almost every important generalization which he made, and right (within the resources of his time) in every constant he established. Chemistry without his contributions would yet be a mere scaffolding.

The history of this controversy, the most important which has taken place since the commencement of the

modern science, is useful as an illustration of another kind of hindrance to the progress of intelligent theory. It is a too blind devotion to one man, and despair of attaining the object which he strove for if he has failed. It is true that if ever hero worship were justifiable that of Berzelius was, but to sweep aside the whole fabric of his labors, because part of his theory was proved untenable, was the veriest cowardice and injustice to him.

How many a chemist in the last forty-five years has struggled through a jungle thick planted with the pretty crochets of mediocre men, wondering what all this jargon meant and whither it was tending; deprived of the vivifying influence of a high and noble thought, and condemned to delve and grub without reasoning, because one of the greatest geniuses of original research the world has ever seen was worsted in an encounter on a small part of his field, and a part to which he had not devoted the best of his thought!

Among the most innocent looking hindrances to the development of sound chemical theory must be reckoned an hypothesis, which was given anonymously to the world in 1815, and which was later referred to its true author, Dr. Prout. This was the supposition that the atomic weights of all elements were even multiples of that of hydrogen.*

No argument was offered to show why this should be true, but it had the specious and enticing appearance which captivates that sense of order which is a human instinct.

Prout did not hesitate to add the obvious conclusion that hydrogen was the original material, or as one of the greatest of living chemists has put it, the protyle.

By the usual rule which exists in such cases Prout should not have had credit for anything more than a pretty idea which besides was only a modification of a similar thought of Thomson the collaborator of Dalton, who believed

* It should be stated that Profs. Crookes, F. W. Clarke and other chemists of the first rank still show a leaning towards the acceptance of something like Prout's "law."

that the atomic weights of the elements were multiples of that of oxygen. Prout was more nearly right, of course, because the weight of hydrogen is only about one-sixteenth as great as that of oxygen, and is a more general divisor. But in spite of all, this pretty thought strongly influenced many admirable chemists, even those like Dumas and Stas and Marchand and Erdmann, whose labors in accurately determining atomic weights did more than all else to prove the baselessness of Prout's assumption.

Even to-day the tendency is manifested to get back to the even numbers which Leopold Gmelin adopted in his great work, in entire disregard of the accurate results of Berzelius. It must be added that some are prevented from falling into this snare through the hope that the real protyle will be some day discovered, and that being lighter than hydrogen it will provide a table of atomic weights less disfigured by fractions than the present one.

The moral of this theory is that healthy scientific work must not be influenced by premature attempts to put a finish on it and make it appear symmetrical.

The discovery of an element lighter than hydrogen and possessing properties which, as it will be seen, we can to a certain degree predict, might render very desirable those ugly decimal affixes to the present atomic weights in order to show that experiment supported theory. On the whole Prout's "law" as it is called is a hindrance and quite an annoying one.

The downfall of dualism and the establishment of unitism in compounds was followed by a storm of conflicting notions of chemical union into all of which it is not necessary to enter.

To Laurent and Gerhardt is due the praise for unifying in the new theory of types, the opinions which had been previously thought to be diametrically opposite. It has been said that the uncertainty which prevailed upon the overthrow of the dualistic theory of Berzelius caused most chemists to go back to the old equivalent weights $O = 8$, but Gerhardt opposed this weakness and strongly maintained the correctness of the numbers of Berzelius, merely correcting

his early atomic weights for the alkaline metals in conformity with the then acquired knowledge of the existence of two atoms of the metal in the alkalies. He showed that the quantities of $H_2O$,$CO_2$ etc., separated in the reactions of organic compounds did not represent one equivalent each, but two. His aim was to reduce all formulas to one criterion which in the case of gaseous substances was two volumes. His view was that, when two bodies react, one constituent of one (H), uniting with one constituent of the other (O), leaves two residues which unite. Hofmann discovered the substitution products of ammonia and thus established the ammonia type. Williamson established the water type and referred alcohols, ethers, acids, bases and salts to this type. Gerhardt recognized the hydrogen type, the water type, and the ammonia type, but considered the compounds under them units and not couples.* Laurent explained the atom as the least part of matter that can take part in chemical combination; the molecule as the least part which can exist alone, and the equivalent of elements as those quantities which would perform the same amount of chemical work.

Thus the new-type theory was a compromise skilfully constructed to save the Berzelians from chagrin while embodying all of value in their system. It took the idea of type from Dumas, that of radicle from Berzelius, but with the difference that it did not presuppose the groups of atoms called radicles to be necessarily capable of existing alone. Gerhardt admitted that the elements substituted in radicles did change the character of the compound.

Kekulé, in the year of Gerhardt's death (1857), added the conception of mixed types.

It is unnecessary to pursue this branch of the theory farther. An entirely new discovery appeared which was a

* Dr. Wolcott Gibbs, in 1858, after referring to his attribution of the theory of water types to Gerhardt and Williamson, says: "I have not done justice to T. Sterry Hunt, to whom is exclusively due the credit of having first applied the theory to the so-called oxygen acids and the anhydrides; and in whose earlier papers may be found the germs of most of the ideas on classification usually attributed to Gerhardt and his disciples."—*Chem. and Geol. Essays*, p. 468.

welcome light and enabled many of the obstacles in the way of progress to be seen and surmounted.

Frankland, after an investigation of the alcohol radicles, first announced his views of valence in 1853.

Kolbe, in 1855, accepted his theory and declared that the fatty acids, if imagined free of water, were derivatives of $CO_2$ or $C_2O_4$ in which one atom of oxygen is replaced by $C_2H_3$.

Frankland's discovery was really a corollary of multiple proportions, and had been vaguely foreshadowed by Wöhler, who said that one atom of antimony was equal to three of hydrogen.*

It is simply, as Hofmann expresses it, chemical value in exchange. Some elements, of which H is a type, can only combine one atom to one atom; some, like oxygen, can hold two atoms of the first-named kind in union. Some, like nitrogen, can hold three, and some, like carbon, four. Kekulé, in 1858, determined this valence of carbon, added another to the list of types which led to the establishment of the ring structure of some organic compounds.

Elenmeyer found that every element had a highest valence but might not use all of its combining powers. Wurts and Naquet believed the valence changeable, Kekulé believed it fixed, and that only compounds using all the valences of every constituent were real chemical compounds. It appears to be the general opinion nowadays that the valence of elements is not only variable but that it does not even vary as was supposed by the suppression of two affinities at once (which might be explained as the loss or suppression of one whole polarity); but that an element may be now an artiad and now a perissad, *i. e.*, even or odd in the number of its bonds.

The subject is not well understood, but it presents a good opportunity for acting on the lesson taught by Prout's "law," not to be captivated by a beautiful idea, but to stick closely to facts.

* Von Meyer's admirable and impartial work on the history of chemistry (Leipzig 1889), a most valuable contribution to the science and a fitting supplement to Kopp's, has been largely drawn upon.

It would be impossible at this time to follow all the subsequent contributions to the theory of chemistry, but the most superficial sketch of the subject would be incomplete without studying an extraordinary discovery of which the advent had been preparing long before its announcement by Lothar Meyer and D. Mendelejeff. The latter pointed out that if the atomic weights of the light elements (or those with atomic weights from one to thirty-six) be arranged in two lines of seven each, a natural grouping is effected thus:

Li–7. Be–9·4. B–11. C–12. N–14. O–16. F–19
Na–23. Mg–24. Al–27·3. Si–28. P–31. S–32. Cl–35·5.

In these two lines two periods are passed over. From left to right in each, with the increase of atomic weight is a change from the most electro-positive to the most electro-negative, while the elements in the centre are nearly neutral. Again with the beginning of the second period, elements of the same kind come to stand under one another. The same might be shown to be true in their behavior in forming compounds with oxygen. Again the metals are on the left and the non-metals on the right. The specific gravities increase, and the atom-volumes (or the atomic weights divided by the specific gravities), and all other physical and chemical properties which have been examined, change by regular gradations in vertical or horizontal lines. Without pursuing this subject into its curious details it is apparent that there has been some law exemplified in the production of these elements; a condition of things which is cyclical in its action or, as it is called, periodic. From the data obtained it was possible to construct a table which while containing all the known elements, contained gaps in certain places where (according to the analogy of the periods) elements ought to have been but none had been discovered. From the position of these gaps it was even possible to prophesy from the analogy of elements in similar positions of other periods, that if discovered the new elements filling these gaps would have properties intermediate between those occupying places before and after it, in regard to fusing point, solubility, specific heat, positive or negative polarity, etc.

After the announcement of this periodic law, chemists were impatient for a verification of its accuracy, and in the discovery of the newest metals, gallium and germanium, those predictions were found to have been well founded.

As no better test of a theory can be had than its use as a basis of prediction, the periodic law may be said to have been proved, and to be evidence of a profound and intimate connection between the elements.

What the connection is has not been certainly ascertained, but a bold and beautiful hypothesis was enunciated in 1886, by one of the greatest of the master minds of our age, in his presidential address before the Chemical Section of the British Association for the Advancement of Science, William Crookes.*

A skeleton of the views in this paper is as follows:

Norman Lockyer said that a terrestrial element is an exceedingly complex thing, broken up into simpler things at the temperature of the sun.

Sir Benjamin Brodie in 1867 said, "We may conceive that in a remote time or in remote space there existed formerly or may exist now certain simpler forms of matter than we find on the surface of our globe."

Professor Stokes, in referring to a line in the spectrum of the nebulæ remarks: "It may possibly indicate some form of matter more elementary than any we know on earth."

Crookes holds that the unequal distribution of elements in the earth's crust is evidence in favor of their composite nature.

The probability of such rare metals as yttrium, ytterbium, etc., having been brought together by chance in a few uncommon minerals and in a few localities, is very small. They would rather seem to have been formed severally from some common material placed in conditions in each case nearly identical; and the existence of other groups

* See address of William Crookes, President of the Chemical Section Brit. Ass'n for the Adv. of Science, at the Birmingham meeting, 1886. (R'pt B. A. A. S., 1886, p. 558.)

of metals, as nickel, cobalt, and the two platinum groups furnishes additional ground for this supposition. Another argument in favor of their composite nature is that of the organic compound radicles.

Dr. Carnelly at the previous meeting (1885) had shown that on the supposition of two chemical elements; one with an atomic weight of twelve and the other of two—all the features of peroidicity in Mendelejeff's series could be produced by their combination, and every well-known element reproduced except hydrogen.

Dr. E. J. Mills considered the elements we now have as the result of successive polymerizations.

All these observations Crookes has thrown into a diagram by which is represented the hypothetical condensation of the original "fire mist" out of which the universe was derived and which contained, not matter but the potentiality of matter. In this condensation due to the gradual lowering of the temperature, another force than that of heat was at work—a force which he supposed not very different from electricity. As the temperature was lowered the elements congealed one by one out of the protyle in the form of atoms, of which the weight depended upon the temperature at the time of this formation, and the properties due to the electrical phase at the time of their birth. But the potential energy of the atom was greatest in the first that were thus condensed and more sluggish in the last when the temperature was lowest and the electrical force least.

We must be warned by the very beauty of this conception that it is but the effort of a superior mind to materialize for us the successive phenomena which it sees in imagination, and not a register of observed phenomena or a proven genesis. Yet it is impossible to conceive of the regularity and accuracy with which the labor of a century is fitted into that scheme without feeling that it contains more than a figment of the fancy.

At least nothing greater and nobler has been attempted in our science since its inception, and whether it be finally assigned its place among the great theories of the world or not, it will, undeniably, through its broadening of our

views and its enlarging of our conception, have been a help to the progress of chemical theory.

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In reference to the supposed steam engine prediction, mentioned at the beginning of this lecture, Mr. W. P. Tatham calls my attention to the fact that the actual observation misquoted by the N. Y. *Herald* for sensational or other satisfactory journalistic reasons, and repeated ever since (in spite of countless corrections), after the manner of the average erroneous newspaper paragraph, was made by Dr. Dionysius Lardner and referred to the steamer of that epoch, which, according to his calculation, could only carry coals for a journey of 2,000 miles with due allowance for accident and delay. That he never entertained such an opinion as that above referred to is evident from the following language: "We are even now upon the brink of such improvements as will probably so extend the powers of the steam engine as to render it available as the means of connecting the most distant parts of the earth."

The steam engine familiarly explained and illustrated, etc., by the Rev. Dionysius Lardner, LL.D., F.R.S., pp. 241–242, etc., etc. E. L. Carey and A. Hart, Philadelphia, 1841.

## POSSIBILITIES OF APPLIED SCIENCE.

By Oberlin Smith.

[*A lecture delivered before the Franklin Institute, February 16, 1891.*]

The lecturer was introduced by the Secretary of the Institute, and spoke as follows:

Ladies and Gentlemen:—When the flattering request that I should address this learned Association of the devotees of Science and Art was tendered me by your Secretary, I hastily chose the theme, "Possibilities of Applied Science," as one well fitted to an institution which is, let us hope, a congenial haunt of the spirit of the immortal Franklin. It has occurred to me later, when asked whether I needed a lantern and screen, or other illustrative apparatus, that perhaps the absence of these accessories will cause disappointment to my audience—inasmuch as I have used them here to some extent upon a former occasion, and as many of my fellow-lecturers have thus made for you brilliant expositions of science, after a manner that no speaker can do

by mere words—however eloquent. Possibly the word "Future" should have been prefixed to my title, as some of my hearers may have expected to see illustrated this evening things that, though strange and new, have already been accomplished. Had I been dealing with the science of the present, this expectation might have been fulfilled. As, however, this ground was so well covered by my colleagues in this course, I felt relegated to the *future*, or the *past*. When thinking over the latter theme shall I confess to a hope lingering in my mind that some of our ever-active oriental explorers would soon unearth certain photographs and detailed blue-prints of their work, left in trust to the Franklin Institute by Tubal Cain, Hero of Alexandria and the spear-makers of Cæsar's Rome. From these you should have had lantern slides, but, alas, I found that I had heard in vain Wendell Phillips upon the "Lost Arts," and that I must cry, with Milton,

> "The past, who can recall, or done, undo?
> Not God omnipotent, nor Fate."

Turning to the future for my subject, I was not yet out of my dilemma—finding that even our most progressive amateur "camerists" had found illustrations of this theme to be among the *im*possibilities of science. Mental pictures, however, we may limn, for

> "Time, as he courses onwards, still unrolls
> The volume of concealment. In the future,
> As in the optician's glassy cylinder,
> The undistinguishable blots and colors
> Of the dim past collect and shape themselves,
> Upstarting in their own completed image,
> To scare or to reward."

Could Franklin be with us to-day and see the marvellous developments that have taken place in all branches of science as applied to the arts, in the short century since he reigned as one of the kings among inventors and physicists, can we think he would be skeptical regarding the ultimate fulfilment of any mental prophecies which your lecturer's flights of fancy may lead us mutually into this evening? Would he not excuse us from the charge of being unduly

speculative and visionary, were he to measure the giant's strides, impressed indelibly in footsteps of light, upon the last decade of our history, even deeper than upon its predecessors?

Within this brief period, to say nothing of the many and brilliant inventions which mark the few previous decades of a half a century back, we have seen in our midst the absolute creation of six great commercial industries founded upon electricity alone. I refer to telephony, electric lighting, electric railroading, electric power-transmission, electric welding and electric reduction of metals—notably aluminum. Besides these well-established applications to the purposes of life of that mysterious steed which Franklin loved to harness, any one of which would have marked an era in the earlier ages of our civilization, we are daily hearing of new burdens that this fiery charger is being taught to carry. Among these a few prominent ones that occur to me are electric tanning, electric ore-drilling, electric hoisting, electric warming, electric cooking, electric navigation and tube-making by electro-deposition. With all the hum of electrical industries so constantly about us, it seems difficult to realize that only a score of years ago our practical commercial use of electricity, on a large scale, was limited to telegraphy, electro-plating, bell-ringing, and perhaps the killing of a few farmers, whom the "lightning-rodders," as the genial Stockton calls them, had persuaded to put their rods almost entirely above ground instead of partly below.

Knowing of these marvels in the near past, and of all the other wonders of our century, in all departments of engineering science, and knowing that many of them were, a few years before their appearance, regarded as impossibilities, even by men of science, I do not feel that I am over-visionary in suggesting the things to be mentioned later on as within the realms of possibility. Some of them are more than this; they are probabilities, while not a few may be almost classed as certainties—as far as we can, with our present knowledge, predict their logical future development from their past history.

Who, for instance, knowing that we in Philadelphia now talk distinctly to business associates in Boston or Buffalo, in an ordinary tone of voice, the individuality of which is clearly recognizable, and knowing that even the wisest among us would have declared the thing absurd fifteen years ago, is willing to declare that it is impossible that we shall sometime see each other a thousand miles apart? No one, I think, who has a keen eye for the brilliant analogies which science is ever holding up before us, as object lessons, with which to teach us of her lore.

When, a few sentences back, I spoke of choosing in haste this theme, the expression was used in reference to the fact that it had been found more unmanageable than I at first supposed, on account of certain difficulties in classification. In trying to group under appropriate heads the sub-subjects we wish to examine together this evening, an obvious method seemed to be to treat them as manifestations of science applied to the various arts by which man supplies his wants, and to take these somewhat in their natural order of importance, in the development of civilization out of barbarism. The chief of such wants and desires are: food, clothing, shelter, warmth, light, trade, travel, learning, art and health. This classification is convenient, rather than strictly logical, as some of the terms partly include some of the others.

A more scientific framework for my discourse, but one which, for reasons to be mentioned, seemed likely to result in some confusion, would consist in a system of grouping by the sciences themselves: as, Agriculture, Architecture, Chemistry, Engineering, etc. In trying to analyze the latter term, and fix upon appropriate adjectives for the numerous departments of modern engineering science, I was more than ever impressed with the inadequacy of our nomenclature in the matter of such definitions. In a comprehensive sense this science includes all the others, as applied to the useful arts, and, treating the subject with some degree of logic, we have Engineering, agricultural, textile, architectural, calorific, illuminant, topographical, hydraulic, mining, metallurgical, marine, vehicular, acoustic, aëronautical,

chemical, educational, surgical, diversional, military, etc. The most used adjective of all, "civil" does not appear in this list, because, in its true sense, it includes all the others —except the last named. So also the terms "mechanical" and "electrical" engineer are difficult to define exactly because, according to modern methods, their work enters largely into that of all the others mentioned, and includes part of the military field. Their functions are also somewhat interlocked with each other, so that they are all the time becoming more and more interdependent. From the somewhat awkward list given, which, by the way, is far from complete, it will be seen that the idea involved cannot be carried out without the coinage of certain words which are, to say the least, rather unconventional.

Upon the whole, it seems that the deeper one tries to look into the work of a systematic classification of applied science, the more befogged becomes one's vision. The truth of the entire matter is that we sorely need some congress of dictionary-makers—not only for the fixing with exactitude a meaning for many general scientific terms, but for the establishing of definitions that are definite, for thousands of words pertaining to the details of the technical arts. In ending this digression, it might be fitting to approach the subject proper of my discourse by suggesting that among the brilliant possibilities of the future will be some feat of lexicographical engineering, so to speak, that will apply the rigid logic of our modern chemical nomenclature (which has been the means of so much advancing that science) to the various other branches of technics. Let us all hope for the day when, in the world of science, no two words will mean the same thing, and no two things will be described by the same word.

Following the classification of our subject first proposed, we shall find perhaps in the realm of *food-making* less opportunity for important changes than in any other field of human industry—unless, indeed, we possibly may sometime reach what would be the most radical change in all human development, namely, the artificial production of food from inorganic substances, or even from woody fibre. Such pro-

duction would, of course, tend to utterly revolutionize our agriculture, our fisheries, our stock-raising and game-preservation, together with all the methods of commerce dependent thereupon. A change of this kind seems extremely unlikely to happen for many hundreds or thousands of years to come; and yet, in view of recent developments in chemical synthesis, which prove that many heretofore-considered organic substances can be built up from elements derived in the laboratory from inorganic matter, it will not do for us to rate it as an impossibility. In the making of our present foods we have not, perhaps, very much to learn, because such making is the oldest industry in the world. In the art of cooking them, however, we are still progressing, as we have been since some period following Adam's little pomological experience, wherein the apples received among his wife's morning marketing were probably not baked ones. We shall, no doubt, learn from science many minor improvements in the construction, preservation and distribution of prepared foods of various kinds, all of which will promote their purity and cheapness. In household economy, we shall probably develop the greatest alleviations of domestic drudgery by the use of electricity to do the necessary heating—and perhaps the cooking also. In this, as in other household requirements, to be mentioned later on, the ideal substitute for the bringing in of coal and ice, and the taking out of ashes and drip-water, would be a wire connection with some distant source of electric energy. The mere touching of a switch to exactly regulate the heat necessary for roasting, broiling, baking, boiling, washing and ironing, as for power, warming and lighting, would, indeed, be a household blessing.

In regard to the making of *clothing* (of cloth and other textile materials), we can say, as with food, that the art is so old that there seems scarcely room for more great inventions. There is, however, room for many minor improvements, in methods of manufacture as well as in the fabrics themselves. Undoubtedly, some better way will be contrived to fit garments to the human body than the crude methods now in use of cutting up whole pieces of cloth, at

the expense of considerable waste, into irregular shaped sections which must again be sewed together. Very probably the future may develop automatic methods of weaving or knitting fabrics to the exact shape required, so that they will be entirely seamless. An instance of this is already seen in the seamless stockings, which are knitted by some of the recently improved knitting machinery, and there seems to be no good scientific reason why the same principle should not be carried out to cover the entire field in question. We can easily imagine as practicable some mechanical method of measuring the individual so that the machine would automatically produce a correct fit to order. An analogy for this is seen in the process used by hatters for taking the contour of one's head—only in one plane, however, rather than the many necessary for fitting a coat.

Another possible departure from present methods might consist in some system of chemical or sedimentary deposition, to take the place of the present methods of spinning, weaving and piecing together. The wonders of mechanical chemistry, if we may so term it, are already so great, that we may expect almost anything in the future.

Another line marking a radical change in costume may possibly extend in the direction of fabrics composed partly of diminutive air-cells, so that they can be inflated more or less, and thus a given garment be made suitable for zero-cold or summer's day. This would be something upon the same principle already practised by the birds, who fluff up their feathers as the temperature grows colder. Whether such garments might be made available for life-preservers at sea, by still further inflating them, is a question that must be relegated to their future inventors.

In the matter of *shelter*, or home-building, as we may term it, the race has long had ample experience, and we cannot, of course, expect radical changes in the general principles underlying the art of building. We may, however, and probably shall, develop important improvements in regard to materials of construction and methods of fastening them together. Already we are approaching a "steel

age" in regard to the building art. Whether some still more desirable metal will in time supersede it, is, of course, a question, but it would seem not unlikely that such a metal might be found in some alloy of aluminum—provided it should ever become cheap enough.

Just here it may be well to say a word in reference to the enormous crop of nonsense which has recently been, and is still being, printed in our newspapers in regard to the wonderful capabilities of aluminum as a material for buildings, bridges, ships and other structures where great strength, combined with lightness, is desirable. It is true that this noble and beautiful metal, which has so recently become among us a commercial entity, is only about one-third as heavy as iron, and one-eighth as heavy as gold, weighing only about three times as much as hard wood. Unfortunately, however, it is not much more than one-third as strong as iron or mild steel; and consequently, there is very little gain in using it for structures of the kind mentioned, except for its beauty and non-corrodibility. This is for the reason that, to secure a given strength in a loaded beam, cable or other structure, we must use about three times the bulk that we would in the case of iron or steel. All these facts, however, do not prove that aluminum is not a large component of some coming metal suitable for the purposes in question, and many others requiring great strength and lightness, which lightness, by the way, is not so essential in buildings as it is in bridges, ships and railway cars. A few months since, this statement would not have been so pertinent, as no alloy of aluminum was generally known which was very much stronger than the metal itself, unless made largely of iron, copper or some other heavy metal. Within a few weeks, however, information has been made public regarding certain experiments by the French Government which show the valuable result of an alloy of aluminum with only six per cent. of copper. This is more than double the strength of aluminum alone, while its weight is only about six per cent. greater than the weight of that metal. Thus, at one bound is shown the possibility of a revolution in the design of many structures by adapting them to so valuable a material

as the alloy mentioned. These experiments are, however, probably but the first step toward something still better, which we may expect of the metallurgists of the future. With a material very much lighter, in proportion to its strength, than our present iron and steel, we may certainly expect radical changes in various structures, notably roofs, bridges, and the like, whose span can be much increased when some of the limitations incident to present materials are removed.

With regard to the future cheapening of aluminum, it is difficult to predict. The fact, however, remains that its ores exist all about us in probably greater quantities than those of any other material, and that already its cost has been reduced to one-tenth of what it was less than a dozen years ago. Reasoning by analogy, there seems no good cause why it should not soon be brought down to figures which will compete with copper and brass—and perhaps eventually with steel itself. At all events, there are many cases in which we could afford to pay a much higher price than now for the materials of a structure, for the sake of the advantages gained in design.

In regard to the few, and (at present) rare, metals rivalling aluminum in lightness, such for instance as magnesium, which is perhaps the most common, it is not likely that they can become its rivals for constructive purposes. This is not only on account of their physical characteristics, but also because their ores are probably not so plentiful. What may, however, be done with some of their alloys, we have no data for predicting. Alloy-making is an art in which lies hidden countless capabilities. Indeed, when we consider how the various metals may be combined, both as to number and to quantity, and how easily they are affected by the admixture of non-metallic substances—as, for instance, carbon in steel—the changes that may be rung to produce new and useful alloys seem almost infinite in number.

In predicting further improvements in our buildings, a safe field for flights of fancy is that of automatic conveniences of many kinds, which will undoubtedly be contrived to minister to our comfort and happiness. Among these

will probably be: still better elevators than now; arrangements for water-proof walls, floors and ceilings which can be perfectly purified and cleansed by water or steam jets; automatic heating and cooling arrangements to secure constant temperature and healthful ventilation; perfect control of lighting, to any degree and from various locations; the opening of doors, windows, shutters, shades, mosquito-nets, and other movable devices, by the mere touching of electric buttons, either in the immediate vicinity of the devices named, or from distant parts of the building; easier food-transmission and table service; inter-house telephones and other signals; automatic indicating, in every room, of time, temperature in-doors and out; barometric pressure, direction and force of wind, weather probabilities, etc. Another great desideratum in the future house will probably be obtained by its being made absolutely fire-proof, a result the value of which, to our nerves and to our purses, it is unnecessary to mention.

In the matter of *warmth*, which word I use advisedly, rather than heat, because I wish it to include a certain degree of coolness, there is certainly an inviting field for our future inventors. This subject was touched upon when speaking of buildings, but the improved methods therein desirable would also be required for making comfortable ships, railway cars, carriages, etc. That our present methods of heating by the burning of coal and the non-burning of smoke, and of cooling by carrying in lumps of ice, are crude and wasteful, as well as extremely irregular and uncomfortable, it is not necessary to argue about. It seems probable that in the near future, at any rate for our cities, some system of gas heating will displace coal and wood to a large extent, and this is the more likely from the fact that our streets and houses are already supplied with the necessary pipes, which may perhaps be gradually thrown out of use, as conveyers of illuminating gas, by the improvement and development of electric lighting. There also seems a tendency among inventors in recent years to attempt some kind of artificial cooling by the distribution through pipes of cold air or freezing mixtures of various kinds; also to

contrive cheap ice-making, or other cooling, machines which can be economically used in individual buildings.

All this is in a direct line of progress, but it seems probable that at some time in the future we shall depend upon the electric current brought into each building through a single wire, not only for our lighting and power, but for our heating and cooling also. Just how the latter process is to be accomplished we do not yet know, but, reasoning by analogy, it would not seem outside the range of possibility, when we consider the fact that the burning of coal in a furnace can be made to produce heat or cold at will. It is true that while electric heating in itself has been proved to be perfectly practicable, yet at present it is not economical. This is owing to the fact that our best and largest steam engines by which we run our dynamos utilize only from ten to fifteen per cent. of the energy stored in the coal, lavishly wasting the remainder. Fortunately, our dynamos have reached an efficiency of about ninety per cent., so that there is not much waste in using the electric current after the power to produce it is once generated. It is probable, therefore, that the use of electric heating will for the present be somewhat limited, and confined to special places where its convenience will offset its extra cost. For an extension of its employment thus, as for certain other important uses of electricity, and upon a scale far beyond anything we can now imagine, we must wait until we learn how to produce this current of pure energy from the coal or other fuel direct. Than the accomplishment of this feat, there is to-day no more fascinating problem in the realms of science. Many are working at it, with as yet but small success. We need not despair, however, as it seems to be a logical possibility, and the only thing required is to find out how to do it.

While upon the subject of warmth and coolness, the question naturally arises, shall we ever be able to control our climates, out-of-doors as well as in? At present we can conceive no possible way of doing this, and yet some youth among us, who should positively say that it is an impossibility, might live to realize that it is not well to be too prophetic. We already do something in the way of con-

trolling rain-fall, by regulating forests and inland seas. Practical experiments are about to be tried with explosions high in the air. Who knows what may happen when we learn more about atmospheric electricity?

Regarding *light*, the next subject of my classification: Dame Nature probably has many wonders in store for us, which, so far, it has not pleased her somewhat coquettish majesty to reveal. It is hardly likely that many very brilliant inventions will be made in pine-torches, tallow-dips, kerosene lamps or gas-burners, as the vast superiority of the electric light, even in its present crude state, bids fair soon to abolish all of those antiquated luminaries—especially in and near our cities, and within the range of their electric circuits. The most probable field that occurs to me for inventions of this class is in the way of solidifying petroleum or other cheap illuminants—thus making them more portable. Something I believe has already been done in this line, but how much I know not. Could such a process be made commercially practicable, and could there be some simple method of burning the product with a brilliant steady light, without smoke and without the nuisance of glass chimneys, we should have an ideal light for portable purposes and remote situations. Analogous improvements in tallow and whale-oil are scarcely to be expected, as these materials can never compete with petroleum in quantity and cheapness.

In regard to the improvement of the electric light itself, there does not seem to be a very large field ahead with the two present types that are in practical use, viz: the arc lamp and the incandescent, or "glow" lamp, as our English cousins more appropriately term it. Both of these devices have apparently reached a tolerable degree of perfection, but, so rapid is the development of electrical science, that we must prepare our minds for some radical change of methods at any time. It is well known that there is an excessive loss of energy in both of these systems, even after the steam engine has squandered nine-tenths of its patrimony. Especially is this the case with the glow lamp, which takes nearly ten times as much power, for a given amount

of light, as does the electric arc. The loss of energy in question is obviously due to its dissipation in the form of heat. If, therefore, we can imitate the oft-quoted glow-worm, and view the electric energy in the form of pure light, we shall enormously cheapen this boon of mankind. Many busy, practical brains are now working in this field; and others are approaching it from an abstract scientific standpoint, by trying to discover the inward nature of the mysterious forces known to us as electricity and magnetism. That glorious results will sometime come to us; who can doubt? When they do come, who can predict how great will be the impetus given to manners and to morals, to learning and to art, by a light so cheap that every farm and roadside, in common with every nook and corner of our cities, may, at will, be made to glow with the radiance of day?

## NEW ALLOYS AND THEIR ENGINEERING APPLICATIONS.

BY F. LYNWOOD GARRISON.

[*A lecture delivered before the Franklin Institute, January 30, 1890, and February 6, 1891.*]

MEMBERS OF THE FRANKLIN INSTITUTE, AND LADIES AND GENTLEMEN:

In dealing with the subject of alloys, we have to consider a class of compounds about which, strange as it may seem, we know very little. Although the practice of combining or mixing one metal with another is older than history itself, it cannot be said that at the present time we have any established general laws regulating the subject as a whole. Those who have to do with alloys, generally determine by actual experiment or experience what mixtures and proportions give them the best results for specific purposes. The art of alloyage may therefore be considered as empirical, having little or no basis on scientific fact. I am, of course, speaking in very general terms, as there are many alloys whose properties and peculiarities have

been observed and determined with the greatest scientific care. The subject is a very extensive one when we take in consideration the numerous and varied iron alloys, which, to my mind, constitute the most difficult part of metallurgy.

The varying proportions of the elements present in an alloy are apt to produce such subtle effects that one must always be ready for the unexpected. Again, the properties of an alloy may be much altered by physical means; thus, for instance, the results that a given alloy will produce at ordinary temperatures may be very different from those it will give when heated or cooled. The treatment an alloy has received, such as shocks, strains, etc., will change its qualities to a greater or less degree; the manner in which it has been cast, cooled, rolled or hammered also affects its properties.

Alloys are interesting from a purely scientific standpoint; they are not only mixtures of metals having certain particular qualities, but also in many cases appear to be actual chemical compounds. In the phenomena which accompany the union of some of the metals we observe reactions which characterize the manifestation of affinity, such as an evolution of light and heat, resulting in the formation of substances having a definite composition, distinct crystalline form, and a variety of properties different from those of the constituents. Ordinarily, alloys may be considered to be simple mechanical mixtures of metals or solutions of one or more metals in another. It would also seem probable that certain proportions of one or more of the constituent metals may form definite chemical compounds with each other.

In using the term "new," in the title of these lectures, I mean that it shall be construed broadly, as I am well aware many of the alloys which I shall take up are not strictly new things. Their manufacture, composition and peculiarities are not sufficiently well known, however, to be considered old, although the extent of their use in the arts may be considerable.

I therefore feel it incumbent upon me to mention a few

of them at length, although in some cases they have long since been replaced by newer and better compounds.

The subject we have under consideration is so extensive that I find it will be necessary to divide it into two parts. In the first part, I purpose to confine myself to the copper alloys, such as the bronzes, brasses, etc., and in the second part to iron alloys, or more particularly to the combinations of steel with the various elements, such as nickel, copper, chromium, etc.

The rapid substitution of metals for wood and stone in various engineering constructions, the use of bronzes and other strong elastic alloys in place of cast or wrought iron; or, in short, the vastly more general use of metals in the arts, demands that engineers of all classes shall give much closer attention to the physical properties of these metals and metallic compounds than formerly. It is a mistake for engineers to follow rules of thumb; or, indeed, to adhere rigidly to any rules whatever in this particular. The problem to determine just what particular and peculiar kind of alloy is best suited for a given purpose appears to be a difficult one. The engineer should be governed to a great degree by his judgment, which, to be keen and correct, must be based upon a thorough knowledge of the fundamental laws of physics and chemistry. I am decidedly of the opinion that this most important matter (the physical properties of metals) receives insufficient consideration at the hands of the engineering professions; indeed, it is not improbable that many engineering disasters are due to our ignorance on this score. I cannot see that an establishment or individual is any better off when provided with a testing machine and a chemical laboratory if the results thereby obtained are not properly understood and applied.

Except as a matter of general information, a knowledge of the processes of smelting and refining metals can be of little use to the engineer who is not especially engaged in such work. A knowledge of the physical properties of metals, however, is of the greatest importance. Tensile strength, elastic limit, elongation, reduction of area, etc., should be to him as so many letters of an alphabet, whose

relation to each other in one aspect would mean a very different thing from their relation in another. In like manner, the chemical composition and the effect which the concomitant elements exercise upon the properties of the alloy should be understood. I must state, in connection with this, that, throughout this discourse, I use the word alloy in the broad sense, *i. e.*, a metallic mass composed of various metals in any proportion whatever; thus, for instance, I consider ordinary steel as much an alloy as brass.

I think there is nothing that can more forcibly demonstrate the importance of the subject, than the consideration of the advantages gained by the substitution of mild steel for iron, as, for instance, in the art of ship-building, where the advantages of the use of mild steel scantlings in place of iron is represented by a saving of twenty-five per cent. in the cost of fuel necessary to propel the ship.

The natural and proper tendency of engineers in designing structures is towards a decrease in weight, and at the same time an increase in strength. In order to meet this demand, the metallurgist must produce a material giving greater strength and durability in every particular—and to produce such results it is with these new alloys he will have to deal.

For the sake of convenience, I have divided the alloys I purpose to consider into two general classes, the copper alloys and the iron alloys. While in many instances the same elements are met with in both classes, the proportions are very different, and the system of manufacture, the uses and the peculiarities of the two classes are quite unlike.

## COPPER ALLOYS.

*Copper Alloys* (*Bronze*).—Under this head we have to consider the copper-tin alloys constituting the bronzes proper, the copper-zinc alloys constituting the brasses, and the combinations of the bronzes and brasses with each other and with other elements, such as iron, manganese and phosphorus, in all cases the proportion of copper being in excess of the combined amounts of the other metals present.

The term bronze is usually, and by virtue of long usage,

properly applied to alloys of copper and tin; it is sometimes, however, improperly given to copper alloys containing little or no tin.

How, when and where the admixture of tin with copper to produce bronze was first discovered, is something we cannot hope to ascertain, for history gives us no clue to the mystery. As far back as we can trace, the use of bronze seems to have been common, and its fabrication, both by casting and forging, well understood.

The tools of the ancient Egyptians were generally made of bronze containing twelve parts of tin to eighty-eight parts of copper, doubtless hardened and toughened by hammering. The usual composition of the ancient bronzes was nine parts copper and one of tin; but the proportion of the latter varies from five to fifteen per cent., and in some cases lead has been detected. The use of lead in many of the old Roman bronzes appears to have been somewhat common, and probably it was added to increase their fusibility; it is true also that lead is an economical substitute for tin.

It is a remarkable fact, that even with our present scientific knowledge, we could hardly suggest an improvement upon the general composition of these ancient bronzes; or, with our advanced mechanical practice, surpass the admirable workmanship and beauty of form of some of the various implements of the developed bronze period.

Although the term brass appears in several places in the Old Testament, it probably did not mean an alloy of copper and zinc as we now understand it. The production and use of metallic zinc is comparatively modern, its existence and use as such does not appear to have been known at the time of Pliny, nor indeed at a very much later period. The Romans, according to Pliny, appear to have had the *trick* of giving their bronzes a golden color, by the addition of more or less of the mineral calamine (silicate of zinc—$Zn_2.SiO_4$).

The zinc which found its way into their bronzes was probably by this means, or by the use of some other zinc ore which may have been mixed with the original copper ore, or added subsequently to the copper.

The composition of some of the English brass, of the year 1504, was found on analysis to be—copper, 64 per cent.; zinc, 29½; lead, 3½; tin, 3 per cent.

*Aluminum Bronze.*—Commercial pig copper almost invariably contains more or less dissolved cupreous oxide and occluded gases. The presence of these impurities tends to decrease the ductility of the metal, and their removal produces an astonishing increase in the tensile strength and general ductility.

In this simple fact lies the secret of the excellent results obtained with the improved copper alloys, known as aluminum bronze, phosphor bronze, manganese bronze, deoxidized copper, tempered copper, etc.

Aluminum, phosphorus, manganese, arsenic, silicon and, possibly, iron, when added in various ways to copper, act on these traces of cupreous oxide dissolved in the copper, deoxidizing the same and thus improving and toughening the copper. The slag, containing the oxides of the copper and the other metal or metalloid, resulting from this deoxidation, rises to the surface and can readily be removed.

This is probably the *rôle* aluminum plays in the manufacture of aluminum bronze. Truly it is not such a very remarkable one, when we consider there are nearly a half-dozen other elements which will do exactly the same thing.

Aluminum enthusiasts would have me believe that this property of producing an exceptionally strong ductile alloy, when aluminum is added in certain proportions to copper, is peculiar to aluminum—that such is not the case I hope to prove to you further on.

I cannot, in connection with this, refrain from mentioning the great amount of trash and nonsense which is being continually published about aluminum; if anyone will take the trouble conscientiously to examine into the subject, I think he will find that the field for the application of aluminum, at least in the engineering arts, is not particularly large. To quote one of the best criticisms I have yet seen on the subject: "Its (aluminum) diffusion,

difficult extractibility and remarkable properties seem to have appealed especially to that class of persons whose imaginative powers are largely in excess of their intellectual faculties."* It is not my wish to try to belittle the peculiar and exceptionally valuable intrinsic properties of aluminum, but at a time when so-called processes for its production are being devised and published by the score, it is proper that I should warn engineers and capitalists to be on their guard against charlatans who have invaded this field. There are a number of excellent processes which have been worked out in a scientific manner, such as Castner's, Hall's, Bernard's, and several others, but the most of those we hear about in the newspapers are worthless catch-penny schemes of ignorant or designing people.

Aluminum bronze usually gives the best results when the proportion of its constituents are about ninety per cent. copper and ten per cent. aluminum. With small bars cast in sand, perhaps the best physical test results obtained were: elastic limit, 70,000 pounds per square inch; tensile strength, 95,000 pounds per square inch, with about ten per cent. elongation. With rolled bars much better results have been obtained, more particularly as regards elongation. The modulus of elasticity of aluminum bronze is about 18,000,000 pounds. Specific gravity when cast about 7·56,† when rolled about 7·89.‡

It must not be forgotten, however, that these are *best* results, and that the average run of ten per cent. aluminum bronze will give results somewhat lower than these, and on analysis will very probably be found to contain less than ten per cent. aluminum. This latter fact, however, is only what might be expected if the *rôle* which I have assigned to aluminum is the correct one.

The following analysis of aluminum bronze was made from the material used for firing pins by the Colt Fire Arms Company, of Hartford, Conn. I am indebted for this analysis

* *Engineer*, January 3, 1891, p. 1.

† Cowles Bros.' alloys.

‡ Hunt, *Trans. of the Am. Inst. of Mining Engineers*, vol. xviii, p. 555.

and also for a number of others of different alloys, to Mr. James S. de Benneville, of Dr. F. A. Genth's laboratory:

| | *I.* | *II.* |
|---|---|---|
| | *Per Cent.* | |
| Copper, | 91·260 | 91·260 |
| Aluminum, | 7·410 | 7·410 |
| Silicon, | 0·930 | 0·930 |
| Iron, | 0·220 | 0·301 |
| Lead, | 0·570 | 0·470 |
| Phosphorus, | 0·056 | 0·025 |
| Arsenic, | 0·042 | trace |
| | 100·488 | 100·396 |

The silicon and iron were probably present as impurities in the aluminum. I cannot, however, account for the presence of the lead, phosphorus and arsenic. Very small amounts of lead, however, are sometimes found in commercial aluminum.*

The structure of aluminum bronze is close and dense, and although generally supposed to be workable at a red heat as easily as wrought iron, such, according to competent authorities, is not the case.† It can, it is true, be wrought at a red heat, but according to Richards, it possesses certain peculiarities at that temperature which must be strictly observed.

The melting point of aluminum bronze varies somewhat with the amount of aluminum contained, the higher grades melting at a somewhat lower point than the lower grades. Aluminum bronze shrinks more than ordinary brass. As the metal solidifies rapidly, it is necessary to pour quickly and to have the feeders large. Care must be taken to avoid the oxidation of the liquid metal in transferring to mould.

Aluminum bronze is applicable for a large number of purposes, such as blast-furnace tuyeres, various parts of marine engines, propellers, etc. Also for the firing pins of rifles, and parts of similar structures which are subjected to shocks.

* *Trans. of the Am. Inst. of Mining Engineers*, vol. xviii, p. 530.

† *Richards' Aluminium*, p. 429, Philadelphia, 1890.

*Aluminum Brass.*—Aluminum bronze when added to ordinary brass greatly improves the brass in strength, toughness and resistance to corrosion. According to Messrs. Cowles* "the greater the amount of aluminum bronze added to brass the harder and stronger the brass becomes. Tests have been made where castings of aluminum brass have given as high as 96,000 pounds per square inch in tensile strength." It will be observed the elongation is not stated; it is not a difficult thing to make an alloy of even greater tensile strength, but the elongation will probably be *nil*, and the material so hard and brittle as to be worthless. Messrs. Cowles recommend aluminum brass for the following purposes:†

"Valve and valve-seats for mining pumps, or pumps working under great pressure, worms and worm-wheels, slide-faces, mining machinery, pinions, screws, hydraulic machinery, dredging machinery, gates for turbine wheels, working under a high head, propeller wheels, and as a metal to resist the action of salt water in marine architecture. While aluminium brass is not quite as strong or as tough as the A grade bronze, yet it will answer nearly as well for many purposes that the bronze is used for."

Aluminum brass is stated to have great toughness, rigidity and strength.‡ The ordinary grades have about 85,000 pounds per square inch in tensile strength, with nine per cent. elongation. It is stated to be able to withstand a high temperature without loss of strength.

Recently some interesting experiments were made in the department of aërial navigation at Chalais, Charente, France, which produced some surprising results.§

Alloys of the following composition were made and rolled into sheets one mm. thick; from these, strips five mm. in width were cut and tested.

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* Pamphlet on *The Alloys of Aluminum and Silicon*, p. 26.

† *Ibid.*, p. 25.

‡ *Iron Age*, May 2, 1889, p. 660.

§ *Engineer*, January 2, 1891, p. 2.

| *Al. Per Cent.* | *Cu. Per Cent.* | *Sp. Gr. Calculated.* | *Sp. Gr. Determined.* | *Tensile Strength in Pounds per Square Inch.* |
|---|---|---|---|---|
| 100 | — | — | 2·67 | 26,535 |
| 98 | 2 | 2·78 | 2·71 | 43,563 |
| 96 | 4 | 2·90 | 2·77 | 44,130 |
| 94 | 6 | 3·02 | 2·82 | 54,773 |
| 92 | 8 | 3·14 | 2·85 | 50,374 |

An interesting peculiarity of these alloys is the large divergence between the specific gravities calculated from those of their constituents and the specific gravities directly determined. Each two per cent. of copper might be expected to raise the specific gravity by 0·12, whereas the actual observed increase is only about 0·05.

It will also be observed that the addition of only two per cent. of copper increases the tensile strength from 26,535 to 43,563 pounds per square inch, while six per cent. more than doubles it. Thus it appears that an alloy of aluminum having double the tensile strength of aluminum itself can be made which is less than one-twentieth heavier.

*Manganese Bronze.*—This alloy has been used very extensively for casting propeller blades both in this country and abroad. The best results that I have yet seen obtained with it were the tests of some of the material made by Messrs. B. H. Cramp & Co., of Philadelphia. I have here a number of samples of this manganese bronze, which has been forged, rolled and hammered, both hot and cold. This material when cast in sand has an average elastic limit of 30,000 pounds per square inch, tensile strength of about 60,000 pounds per square inch with an elongation of eight to ten per cent. When rolled the elastic limit is about 80,000 pounds per square inch, tensile strength 95,000 to 106,000 pounds per square inch, and an elongation of twelve to fifteen per cent. These results are obviously excellent, and it is hardly to be expected they could be uniformly obtained, as in ordinary every-day foundry practice sufficient care is not taken to obtain the very best results. They show us, however, that much may be expected of this alloy, and that aluminum bronze is not the only copper alloy which will give us over 100,000 pounds per square inch in tensile strength.

For several years past, manganese bronze appears to have been made in large quantities by Mr. P. M. Parsons, of the Manganese Bronze Company, Deptford, England. Dr. Percy was probably the first to observe the action of the manganese in combining with the traces of cupreous oxide of copper present in the copper, deoxidizing the same, and thus making the metal denser and stronger.

Mr. Parsons, I believe, adds the manganese in the form of ferro-manganese. A portion of the manganese in the alloy thus added is utilized in the deoxidation above-mentioned, while the remainder, together with the iron, becomes permanently combined with the copper. The manganese once alloyed with the copper is not driven off by remelting, but usually the quality of the bronze is improved by a subsequent remelting.*

The Manganese Bronze Company, of Deptford, England, roll and forge the alloy hot. According to Mr. Parsons,† its mean tensile strength as delivered from the rolls is about 67,200 pounds per square inch, with an elastic limit of 49,000 to 51,000 pounds per square inch, and an elongation of from twenty-three to twenty-five per cent. In cold rolling its ultimate tensile strength rises to about 90,000 pounds per square inch, with an elastic limit of 67,200 to 76,000 pounds per square inch, and an elongation of ten per cent. If annealed, the ultimate tensile strength is very little altered, but the elastic limit is reduced about half, and the elongation increased to thirty or thirty-five per cent.

In order to arrive at the practical value of an alloy for engineering purposes, it is necessary not only that it should be subjected to actual use for a length of time, but it is also

* It is interesting in this connection to find that about the year 1868, Messrs. Montefiore, Levi and Künzel, two Belgian chemists, made a number experiments with copper and manganese alloys, and from their results concluded such alloys to be useless. "They obtained great tensile strength and toughness with some of the compositions, but their ready oxidation at high temperatures made the qualities of the castings uncertain and impracticable."—*Journal of the Society of Arts*, May 7, 1877, p. 552.

† *Engineering*, April 20, 1888, p. 398.

necessary that all the strains and conditions under which it is used should be understood as far as possible. Thus, for instance, in the matter of propeller blades, transverse strength has to be considered above tensile, as the first named is the strain to be more particularly provided against. In this strain two forces come into play, tension and compression, but neither of these, separately, gives any indication of the transverse strength of the metal.

The following tables of transverse tests will be found interesting in connection with what has preceded. Nos. 1 and 2 were made at the works of Messrs. Maudsley, Sons & Field, by direction of the British Admiralty.*

A bar of manganese bronze one inch square, laid on supports twelve inches apart, required on an average about 5,000 pounds, applied in the middle, to break or pull it through the supports, as against 2,500 pounds for gun metal.

The above-mentioned bar of manganese bronze (Parsons' No. 2) was made by Parsons' method, at the Manganese Bronze Company's works, at Deptford, London.

The Bronze of Nos. 3 and 4 was made at the works of Messrs. B. H. Cramp & Co., Philadelphia, and the tests at the New York Navy Yard.† .

* *Engineering*, April 20, 1888, p. 398.

† Private communication from Messrs. Cramp & Co.

I.

| Gun Metal. | | | |
|---|---|---|---|
| Strain Applied. | Deflection under Strain. | Permanent Set. | Resilience. |
| *pounds.* | *inches.* | *inches.* | *inches.* |
| 800 | ·03 | — | — |
| 1,000 | ·045 | — | — |
| 1,200 | ·06 | ·013 | ·045 |
| 1,400 | ·09 | ·04 | ·05 |
| 1,600 | ·15 | ·09 | ·06 |
| 1,800 | ·27 | ·20 | ·07 |
| 2,000 | ·46 | ·38 | ·08 |
| 2,200 | ·75 | ·65 | ·10 |
| 2,400 | 1·08 | ·97 | ·11 |
| 2,600 | 1·59 | 1·46 | ·13 |
| | Slipped through supports. Permanent deflection, 3⅝ inches. | | |

A steel bar subsequently tested broke with 5,600 pounds, the total deflection being about ¾ inch.

II.

| Manganese Bronze. | | | |
|---|---|---|---|
| Strain Applied. | Deflection under Strain. | Permanent Set. | Resilience. |
| *pounds.* | *inches.* | *inches.* | *inches.* |
| 800 | — | — | — |
| 1,000 | — | — | — |
| 1,200 | — | — | — |
| 1,400 | ·06 | — | — |
| 1,600 | ·07 | — | — |
| 1,800 | ·08 | ·005 | ·075 |
| 2,000 | ·09 | ·01 | ·08 |
| 2,200 | — | — | — |
| 2,400 | — | — | — |
| 2,600 | — | — | — |
| 2,800 | — | — | — |
| 3,000 | ·20 | ·075 | ·125 |
| 3,200 | ·23 | ·105 | ·125 |
| 3,400 | ·28 | ·140 | ·140 |
| 3,600 | ·34 | ·19 | ·15 |
| 3,800 | ·41 | ·26 | ·15 |
| 4,000 | ·49 | ·33 | ·16 |
| 4,200 | ·59 | ·425 | ·165 |
| 4,400 | ·7 | ·53 | ·17 |
| 4,600 | ·81 | ·63 | ·18 |
| 4,800 | 1·16 | ·96 | ·20 |
| 5,000 | 1·39 | 1·17 | ·22 |
| 5,200 | 1·7 | 1·47 | ·23 |
| | Fractured, permanent deflection 3 3-16 inches. | | |

The following transverse tests of Cramp's manganese bronze were from the pouring gate for the propeller hub of the U. S. S. *Maine*, Navy Yard, New York, May 16, 1890.

Ten inches between supports. Loads applied on the centre. On specimen III the loads were applied and allowed to remain two minutes before the deflection was measured, after which the loads were removed and the recovery measured. The above operations were repeated

with each load until 3,750 pounds were applied, when the deflection was so great as to allow the specimen to rest on the edges of the blocks, after which the recovery was not measured, and the load was increased until the specimen broke. Specimen IV was tested, as shown in the table:

III.

*Placed in position measured 10·562". Section of III 1·009 by 1·013".*

| Load. | | | | |
|---|---|---|---|---|
| Lbs. Total. | Spec. Measured. | | Spec. Deflected. | |
| | On. | Off. | On. | Off. |
| 500 | 10·527 | 10·562 | 0·035 | none |
| 700 | 10·520 | 10·562 | 0·042 | none |
| 800 | 10·517 | 10·562 | 0·045 | none |
| 900 | 10·509 | 10·562 | 0·053 | none |
| | | | | Perm. set. |
| 1,000 | 10·507 | 10·555 | 0·055 | 0·007 |
| 1,300 | 10·484 | 10·545 | 0·078 | 0·017 |
| 1,400 | 10·480 | 10·540 | 0·082 | 0·022 |
| 1,600 | 10·460 | 10·532 | 0·102 | 0·030 |
| 1,800 | 10·437 | 10·517 | 0·125 | 0·045 |
| 2,000 | 10·378 | 10·485 | 0·184 | 0·077 |
| 2,200 | 10·358 | 10·478 | 0·204 | 0·084 |
| 2,500 | 10·256 | 10·382 | 0·366 | 0·180 |
| 2,750 | 10·140 | 10·290 | 0·422 | 0·272 |
| 3,000 | 9·810 | 9·995 | 0·752 | 0·567 |
| 3,500 | 9·286 | 9·485 | 1·276 | 1·077 |
| 3,750 | 8·689 | — | 1·873 | 9" betw. sup'rts. |
| 6,300 | 8·540 | Broke. | 2·022 | |

IV.

*Placed in position measured 10·562". Section of IV 1·007 by 1·0115".*

| Load. | | | | |
|---|---|---|---|---|
| Lbs. Total. | Spec. Measured. | | Spec. Deflected. | |
| | On. | Off. | On. | Off. |
| 1,150 | 10·507 | 10·556 | 0·055 | 0·026 |
| 2,000 | 10·404 | 10·523 | 0·158 | 0·089 |
| 2,500 | 10·247 | 10·400 | ~0·315 | 0·162 |
| 3,000 | 9·918 | 10·083 | 0·644 | 0·479 |
| 3,500 | 9·598 | | 0·964 | 9" betw. sup'rts. |
| 6,400 | 8·079 | Broke. | 2·483 | |

| Specimen. | Applied Load. | | Deflection in Inches. | Sp. Gr. | Hardness. | Bent before Breaking. | Remarks. |
|---|---|---|---|---|---|---|---|
| | Total. | Maximum Fibre Strain. | | | | | |
| 3 | 6,300 | 82,150 * | 2·022 | 8·24 | 1·52173 | 24°-07" | |
| 4 | 6,450 | 84 530 * | 2·483 | 8·18 | 1·6279 | 28°-48'-30" | |

* From formula $f = \frac{3}{2} \cdot \frac{W l}{b h^2} \cdot \frac{l}{9''}$

TENSILE TESTS—CRAMP'S MANGANESE BRONZE.

*Cast in Sand.*

| | Size Diameter. | Area in Square Inches. | Tensile Strain, Pounds per Square Inch. | Limit of Elasticity in Pounds per Square Inch. | Elongation. Per Cent. | Reduction of Area. |
|---|---|---|---|---|---|---|
| 1 | ·631 | ·3127 | 60·154 | 33·579 | 12·5 | 9·6 |
| 2 | 1·00 | ·7854 | 48·510 | 26·730 | 9·2 | 13·5 |
| 3 | ·645 | ·32674 | 63·735 | 34·278 | 6·0 | 10·5 |
| 4 | ·749 | ·4406 | 59·910 | 31·040 | 11·6 | 18·7 |
| 5 | ·6234 | ·30514 | 63·249 | 39·326 | 2·5 | 3·5 |
| 6 | ·746 | ·4370 | 63·730 | 37·2.0 | 7·6 | 11·9 |

*Rolled Bars.*

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | ·636 | ·317 | 106·056 | 82·019 | 17· | 21·5 |
| 8 | 638 | ·3197 | 98·340 | 86·645 | 14· | 25·7 |
| 9 | ·743 | ·4336 | 93 200 | 59·960 | 21·2 | 28·1 |
| 10 | ·744 | ·4347 | 85·410 | 64·870 | 20· | 23·6 |
| 11 | ·634 | ·3157 | 101·299 | 88·850 | 10·5 | 17·7 |
| 12 | 1·004 | ·7917 | 94·230 | 87 150 | 8·6 | 14·1 |

*Compression tests of Cramp's Manganese Bronze (cast in sand).*—Tests were made at United States Navy Department from the metal in the pouring gate of propeller hub of U. S. S. *Maine*. These test pieces were cut from the specimens which had already been tested to destruction under transverse stress, and the results are undoubtedly lower than would be shown by metal which had not been previously strained.

The specimens were 1 inch high by 0·7 x 0·7 inch in cross-section = 0·49 square inch.

Both specimens gave way by shearing, on a plane making an angle of nearly 45° with the direction of stress.

| | *Load Applied.* | *Crushing Stress per Square Inch.* |
|---|---|---|
| A, | 61,950 lbs. | 126,450 lbs. |
| B, | 66,500 " | 135,750 " |

A subsequent test on a specimen 1 x 1 x 1 inch was made from a piece of the same pouring gate, but which had not been previously strained. Under stress of 150,000

pounds it was flattened to 0·72 inch high by about 1¼ x 1¼ inches; but without rupture or any sign of distress, showing the interior to be homogeneous and without flaws.*

*Torsion tests of Cramp's Manganese Bronze (cast in sand).*—The following is a copy of report to the Commandant of New York Navy Yard:

NAVY YARD, NEW YORK, February 14, 1889.

SIR:—In obedience to your order of the 16th ultimo, a copy of which is hereto attached, we have tested for torsional strength two pieces of Vesuvius metal,† one rolled and one cast, and beg leave to report as follows:

The test specimens were turned to the form shown in the sketch furnished by the Bureau, and reduced to three-fourths and fifteen-sixteenths inch diameter between fillets, respectively.

The one cast while being reduced from one and one-fourth inches (diameter of the ends) to fifteen-sixteenths of an inch, developed a number of small blow-holes for the entire length between fillets.

Some of these were nearly cleaned up by the finishing cut, while others were just developing, their depth varied from one-sixty-fourth to one-thirty-second of an inch.

After being turned to their respective sizes, levers of forty-eight and eight inches, respectively, were keyed on each end. The test pieces were then put on the centres of a heavy lathe, the long lever towards the tail stock, and the short lever towards the face plate end, the small lever brought up against a lug on face plate which securely held the piece in position.

A Z-bar was then bolted to the carriage of the lathe, about the centre of the long lever. A sliding plate, with a knife edge, working freely in a slot in the bar was brought up to the bottom side of the lever whilst in its horizontal position, the knife edge just touching it. This enabled the observer to sight between the knife edge and lever, and see

* Private communication.

† Cramp's manganese bronze.

that it was kept floating in a horizontal position for the required time.

On the side of the lathe opposite to where the weight was applied, and while the lever was horizontal, a zero mark was made on the periphery of the face plate (diameter 46·26 inches) squared from the carriage of the lathe.

Before commencing test, 2·92 pounds was added to scale pan in order to bring the equivalent weight on end of lever up to ten pounds.

The increments were then added and the lathe turned slowly by hand, just sufficiently to keep the lever horizontal, by means of the back gear; another mark was then made on the periphery. At the end of two minutes the load was removed and another mark was made, and so on, for each increment.

When the amounts of torsion in the piece rolled was 3,120 ($F = 37{,}717$), and in the piece cast 3,360 ($F = 20{,}797$) inch pounds, the lever in each case supporting the weight but a short time and then slowly settled down on the knife edge; the same condition prevailed for the subsequent moments until the breaking stress was reached.

The elastic limit was not clearly defined, but the Board thinks that it occurred where the first permanent set showed itself, viz: in the piece rolled between moments of torsion 1,440 and 1,680 ($F = 17{,}408$ and $F = 20{,}309{\cdot}4$), and in the piece cast between moments 1,920 and 2,400 ($F = 11{,}884$ and $F = 14{,}855$).

The calculations in connection with the tests, together with diagram showing curves of torsion and permanent set, are hereto attached.

Very respectfully,

J. J. BARRY, *P. A. Engineer, U.S.N.*
F. H. BAILEY, *P. A. Engineer, U.S.N.*
J. L. WOOD, *Ass't Engineer, U.S.N.*

*To the Commandant,*
*Navy Yard, New York, N. Y.*

Commandant's Office, Navy Yard, New York, approved February 15 1889.

F. M. RAMSAY,
*Captain Commanding.*

| Description of Test Piece. | Vesuvius Metal * Cast. | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of smallest Part. | 1.8″ | | | | | | | | | | | | | | | | | |
| Length between Fillets. | 4″ | | | | | | | | | | | | | | | | | |
| Length Lever between Centre and Point where Wt. is Applied. | 4″ | | | | | | | | | | | | | | | | | |
| Moment of Lever alone in Inch-pounds. | 340·1250 | | | | | | | | | | | | | | | | | |
| Limit of Elasticity in Inch-pounds. | Between Moments of Torsion 1920 and 2400 ($F = 11884$ and $F = 14855$). | | | | | | | | | | | | | | | | | |
| Breaking Stress in Pounds per Square Inch. | 51478 | | | | | | | | | | | | | | | | | |
| Number. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Equivalent Weight on End of Lever. | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 |
| Distance of Mark on Face Plate from Zero. Load on. | 0 | 3·16 | 11·32 | 9·16 | 29·32 | 1 7·16 | 2 7·8 | 5 5·8 | 9 9·16 | 14 5·8 | 20 1·4 | 26 13·16 | 34 1·8 | 42 1·16 | 50 11·16 | 61 1·8 | 72 1·2 | 77 9·16 |
| Distance of Mark on Face Plate from Zero. Load Removed. | 0 | 0 | 0 | 0 | 7·32 | 17·32 | 1 3·4 | 4 5·16 | 8 1·16 | 13 | 18 1·4 | 24 5·8 | 31 9·16 | 39 5·16 | 47 3·4 | 58 | 69 3 16 | Broke. |
| Torsion Angle from Zero. Load on. | 0 | ·46° | ·85° | 1°·39 | 2°·24 | 3°·56 | 7°·11 | 13°·91 | 23°·65 | 36°·17 | 50°·08 | 66°·31 | 84°·39 | 104°·02 | 125°·35 | 151°·16 | 179°·09 | 191°·81 |
| Torsion Angle from Zero. Load Removed. | 0 | 0 | 0 | 0 | ·54° | 1°·31 | 4°·33 | 10°·67 | 19°·94 | 32°·15 | 45°·13 | 60°·90 | 78°·06 | 97°·22 | 118°·09 | 143°·43 | 171°·10 | Broke. |
| Twist of Piece Measured on Circle 12″ Radius. | 0 | ·036 | ·178 | ·291 | ·465 | ·746 | 1·489 | 2·911 | 4·953 | 7·575 | 10·489 | 13·889 | 17·675 | 21·786 | 26·253 | 31·659 | 37·540 | 40·179 |
| Moment of Torsion-Inch-pounds. | 480 | 960 | 1440 | 1920 | 2400 | 2880 | 3360 | 3840 | 4320 | 4800 | 5280 | 5760 | 6240 | 6720 | 7200 | 7680 | 8160 | 8640 |
| Value of $F$ from $M = \frac{fd^3}{5{\cdot}1}$ $F = \frac{48 \times W \times 5{\cdot}1}{{\cdot}9375^3}$ | 3971 | 5948 | 8913 | 11884 | 14855 | 17826 | 20797 | 23768 | 26739 | 29710 | 32681 | 35652 | 38623 | 41594 | 44565 | 47536 | 50507 | 53478 |
| Angle of Recovery. | 0° | ·46° | ·85° | 1°·39 | 1°·70 | 2°·85 | 2°·78 | 3°·24 | 3°·71 | 4°·02 | 4°·35 | 5°·41 | 6°·33 | 6°·80 | 7°·26 | 7°·73 | 8°·19 | — |

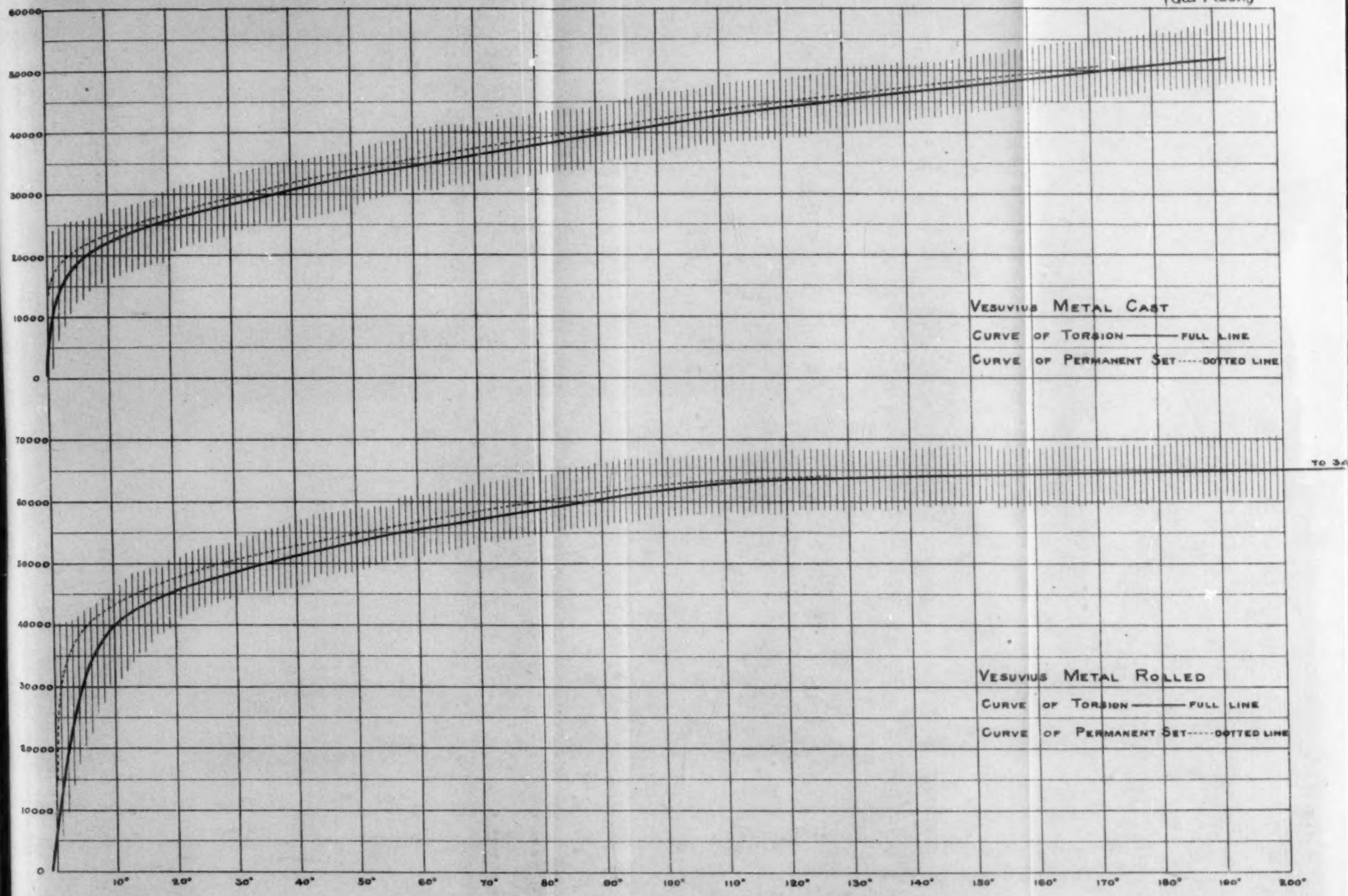
* The Cramps call their manganese bronze Vesuvius metal.

| Description of Test Piece. | Vesuvius Metal * Rolled. | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of smallest Part. | ¾″ | | | | | | | | | | | | | | | | | | | | | |
| Length between Fillets. | 4″ | | | | | | | | | | | | | | | | | | | | | |
| Length Lever between Centre and Point where Wt. is Applied. | 4″ | | | | | | | | | | | | | | | | | | | | | |
| Moment of Lever Alone in Inch-pounds. | 340·1250 | | | | | | | | | | | | | | | | | | | | | |
| † Between Moments of Torsion 1440 and 1880 ($F = 1740$ and $F = 2030{\cdot}4$) Limit of Elasticity in Inch-pounds. | | | | | | | | | | | | | | | | | | | | | | |
| Breaking Stress in Pounds per Square Inch. | 66730 | | | | | | | | | | | | | | | | | | | | | |
| Number. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Equivalent Weight on End of Lever | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 |
| Distance of Mark on Face Plate from Zero. Load on. | 0 | 3-16 | 3-8 | 17-32 | 3-4 | 15-16 | 1 3-16 | 1 7-16 | 1 25-32 | 2 1-8 | 2 9-16 | 3 1-4 | 4 11-32 | 6 3-16 | 9 1-32 | 13 1-8 | 17 31-32 | 23 5-8 | 30 1-2 | 38 5-8 | 54 3-4 | 139 |
| Distance of Mark on Face Plate from Zero. Load Removed. | 0 | 0 | 0 | 3-32 | 3-32 | 5-32 | 1-4 | 5-16 | 15-32 | 5-8 | 15-16 | 1 7-16 | 2 3-8 | 4 1-16 | 6 11-16 | 10 9-16 | 15 1-4 | 22 23-32 | 27 11-32 | 35 11-32 | 51 | Broke |
| Torsion Angle from Zero. Load on. | 0 | 46° | 93·0 | 10·31 | 10·85 | 20·32 | 20·93 | 30·56 | 40·41 | 50·46 | 60·34 | 80·04 | 100·74 | 150·30 | 220·34 | 320·46 | 440·44 | 580·43 | 750·43 | 950·53 | 1350·41 | 3430·77 |
| Torsion Angle from Zero. Load Removed. | 0 | 0 | 0 | 0 | ·23° | ·23° | ·31° | ·62° | ·77° | 10·16 | 10·55 | 20·32 | 30·56 | 80·05 | 160·5 | 260·43 | 370·72 | 510·74 | 670·63 | 870·41 | 1260·43 | Broke |
| Twist of Piece Measured on Circle 12″ Radius. | 0 | ·097162 | ·194325 | ·275233 | ·388650 | ·485812 | ·615362 | ·744912 | ·903043 | 1·101175 | 1·304887 | 1·684150 | 2·250931 | 3·206362 | 4·679993 | 5·726775 | 9·311406 | 12·748475 | 15·805100 | 20·015475 | 28·371470 | 72·029800 |
| Moment of Torsion-Inch-pounds. | 480 | 720 | 960 | 1200 | 1440 | 1680 | 1920 | 2160 | 2400 | 2640 | 2880 | 3120 | 3360 | 3600 | 3840 | 4080 | 4320 | 4560 | 4800 | 5040 | 5280 | 5520 |
| Value of $F$ from $M = f\frac{d^3}{5{\cdot}1}$ $F = \frac{48 \times W \times 5{\cdot}1}{.75^3}$ | 58021·0 | 87410 | 116050 | 145067 | 174080 | 203094 | 232111 | 261118 | 290131 | 319144 | 348150 | 377170 | 406190 | 435200 | 464210 | 493230 | 522240 | 551250 | 580270 | 609280 | 638290 | 667300 |
| Angle of Recovery. | 0 | 0·46 | 0·93 | 1°08 | 1°62 | 1°93 | 2°31 | 2°79 | 3°25 | 3°71 | 4°02 | 4°48 | 4°87 | 5°25 | 5°84 | 6°34 | 6°72 | 7°19 | 7°80 | 8°12 | 9°28 | — |

* The Cramps call their manganese bronze Vesuvius metal.

† This Moment of Torsion ought to be 960. Giving for a value of $F$ 11605.

(Garrison)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TO 3
VESUVIUS METAL CAST
CURVE OF TORSION ——— FULL LINE
CURVE OF PERMANENT SET ----- DOTTED LINE
VESUVIUS METAL ROLLED
CURVE OF TORSION ——— FULL LINE
CURVE OF PERMANENT SET ----- DOTTED LINE

The Directors of the Peninsular and Oriental Steamship Company some few years ago decided to fit one of their steamers with a set of manganese bronze blades, and in order to arrive at the correct value of the advantage of this metal over steel, it was decided to take off the steel blades that had been in use four years, the performance of which had been carefully noted, and replace them with bronze blades, cast by the Manganese Bronze Company, of Deptford, of the same diameter, pitch and area, and in every way duplicate, except thickness of material and fine cleavage edge. These blades were satisfactorily cast and fitted to the steamship *Balaarat*, from which the following results were obtained.

| | *Speed Knots.* | *Coal per Day, Tons.* | *I. H. P.* | *Slip Per Cent.* |
|---|---|---|---|---|
| Steel Blades, . . . . . | 12·11 | 63·8 | 2·828 | 13·1 |
| Bronze " . . . . . | 12·35 | 55·0 | 2·577 | 9·7 |

The advantages thus gained by the use of manganese bronze represent a saving of 700 tons of coal on the round voyage.*

One of the great objections to the use of manganese bronze, or in fact any alloy except iron or steel, for the propellers of iron ships is on account of the galvanic action set up between the propeller and the stern-posts. This difficulty has in great measure been overcome by putting strips of rolled zinc round the propeller apertures in the stern frames.

*Manganese Bronze Tubes.*—A manganese bronze tube, similar to those used in hydraulic gun carriages, was recently subjected to a severe test by Armstrong, Mitchell & Co., England. The tube was 4·9 inches outside diameter, 0·3 inch thick and 18 inches long. An internal pressure of 4,000 pounds per square inch was applied without increase of outside diameter; 5,000 pounds pressure produced an enlargement of 0·03 inch; 6,000 pounds pressure increased the diameter 0·08 inch. The testing pump could not go beyond this pressure, so the tube was turned off to an outside diameter of 5·55 inches, leaving it 0·125 inch in thickness. A pressure per square inch of 1,000 pounds produced

* *Trans. of the Institution of Naval Architects*, 1888, pp. 378, 379.

no change of diameter; 2,000 pounds pressure increased the diameter 0·1 inch; 2,500 pounds pressure burst the tube. Two longitudinal specimens were taken from the tube and tested for tensile strength. They gave an ultimate strength of 31·5 tons (70,560 pounds) per square inch and a stretch of 27½ per cent. in 3 inches. Some of the advantages claimed for tubes made from this metal are freedom from the pitting and corrosion experienced with steel, and a strength when annealed double that of the best copper. For the same strength manganese bronze tubes weigh about one-half that of copper or brass, and cost about one-third less per running foot.*

Parsons makes five grades of manganese bronze, the first of these is used wherever strength is wanted, the fourth and fifth only for anti-friction purposes.

No. 1 is the only grade which cannot be cast in sand. It is used entirely in the forged, rolled and drawn condition. The ingots for this purpose are cast in chill moulds in the usual manner. As manganese bronze is but very slightly affected by the corrosive action of impure water, this grade is well adapted for propeller studs, piston rods, centrifugal pump spindles, etc. It is also well adapted for stampings of all kinds and for bolts of different sizes.

Parsons' manganese bronze No. 2 is designed for purposes where strength and toughness are required, but in which the form of the article necessitates casting, such as propeller blades, cylinders for ordnance, hydraulic rams, gun-mountings, etc.

The strength of No. 2 Parsons' manganese bronze cast in sand averages about as follows: elastic limit, 35,000 to 43,000 pounds per square inch; tensile strength, 63,000 to 75,000 pounds per square inch; elongation, from thirteen to twenty-two per cent. in five inches.

The following analysis of this No. 2 bronze was made from a chip off of the propeller of Mr. W. K. Vanderbilt's yacht *Alva*.†

* *Engineering and Mining Journal*, January 31, 1891, p. 146.

† This analysis was made by Mr. James S. DeBenneville, in Dr. Genth's laboratory.

| | |
|---|---|
| Copper, | 88·644 |
| Zinc, | 1·570 |
| Tin, | 8·700 |
| Iron, | 0·720 |
| Lead, | 0·295 |
| Phosphorus, | trace |
| | 99·929 |

It will be observed there is no manganese present and the amount of zinc is very small. I have a number of analyses of different kinds of manganese bronze, and I note the presence of very small amounts of phosphorus in all. I am unable to account for its presence, unless it was originally in the pig copper.

Tests of transverse strength by impact of this grade (No. 2) of manganese bronze, of gun metal and of steel are as follows: The impact tests were made by a weight of fifty pounds falling on the middle of the bar from a height of five feet, the bar resting on supports twelve inches apart.

The manganese bronze broke with thirteen to seventeen blows, the deflection at the eighth blow averaging 3·60 inches.

The gun metal broke with seven to eight blows, the deflection after the fifth blow averaging 3·65 inches.

The steel broke with three blows, deflection 0·66 inches.* The quality of steel is not stated.

The gun-metal bars were cast by Messrs. Maudsley, Sons & Field, of the strongest mixture that could be obtained. The steel bars were cut from the thin end of a propeller blade. It will be seen from the transverse experiments previously given that the manganese bronze has about twice the strength of the gun metal. It required one ton to give the manganese bronze bars a permanent set of ·01 inch in twelve inches, whereas the gun-metal took a set of 0·15 inch with twelve hundredweight. It will also be observed that its resilience is about the same proportion, viz: nearly twice that of gun metal. It should be observed that although the steel bar required 2,000 pounds more to break it by steady pressure than the manganese bronze bar, it

* *Parsons' Manganese Bronze Catalogue*, 2d ed., p. 41.

was a long way behind when tested by impact, the work done in breaking the latter being much more than in the former.*

In *Figs. 1, 2* and *3*, we have shown several manganese bronze propellers cast by Messrs. Cramp. They were hammered and bent cold under a steam hammer to test the ductility of the metal.

### COPPER-ZINC-IRON ALLOYS.

*Delta Metal.*—This alloy, which was formerly known as sterro-metal,† is composed of about sixty parts of copper, from thirty-four to forty-four of zinc, from two to four of iron, and from one to two of tin.‡

The peculiarity of all these alloys is the content of iron which appears to have the property of increasing their strength to an unusual degree.§ In making delta metal

| I | | II. | |
|---|---|---|---|
| | *Per Cent.* | | *Per Cent.* |
| Iron, | 0·1–5 | Iron, | 0·1–5 |
| Copper, | 50–65 | Tin, | 0·1–10 |
| Zinc, | 49·9–30 | Zinc, | 1·8–45 |
| | | Copper, | 98–40 |

the iron is previously alloyed with zinc in known and definite proportions. When ordinary wrought iron is introduced into molten zinc, the latter readily dissolves or absorbs the former, and will take it up to the extent of about five per cent. or more. By adding the zinc-iron alloy thus obtained to the requisite amount of copper, it is possible to introduce any definite quantity of iron up to five per cent. into the copper

* *Parsons' Manganese Bronze Catalogue*, 2d ed., p. 41.

† Percy's *Metallurgy of Iron and Steel*, p. 157.

‡ What is known as Aich's metal is practically the same thing.

§ Delta metal appears to be a patented compound, but as it is exactly the same composition as sterro-metal which was introduced many years ago by Baron Rosthorn, of Vienna, it is difficult to see upon what patentable claim it can be based. Percy mentions at length sterro-metal and similar alloys in his *Metallurgy of Iron and Steel*, published in 1864. I find Delta metal was patented by Dick, in 1882. (British Patent, No 2,484, 1882, amended December, 1889). According to the specification the alloy may or may not contain tin, and it may have the variable composition indicated above.

FIGS. 1, 2, 3.—Manganese-bronze propellers. Tested cold under the steam-hammer.

alloy. Hiorns* states that the inventor (Mr. Dick) uses a small amount of phosphorus in combination with the copper to avoid the oxidation when the alloy is remelted. In some cases he uses tin, manganese and lead to impart special properties. The inventor claims that by his process the iron is chemically combined in the brass and bronze.

The advantages claimed for delta metal are great strength and toughness. It produces sound castings of close grain. It can be rolled and forged hot, and can stand a certain amount of drawing and hammering when cold. It takes a high polish, and when exposed to the atmosphere tarnishes less than brass.

When cast in sand delta metal has a tensile strength of about 45,000 pounds per square inch, and about ten per cent. elongation; when rolled, tensile strength of 60,000 to 75,000 pounds per square inch, elongation from nine to seventeen per cent. on bars 1·128 inch in diameter and 1 inch area.†

Wallace gives the ultimate tensile strength 33,600 to 51,520 pounds per square inch, with from ten to twenty per cent. elongation.‡

In *Fig. 4* we have shown a composite propeller blade made by the Delta Metal Company, London. It consists of annealed cast steel, upon which is cast a comparatively thin outer coating of delta metal or bronze. It is claimed that in casting the delta metal on the steel the former becomes to a certain extent chilled, and then has its ultimate tenacity considerably increased. This combination is claimed to give the blade great strength to resist cross-breaking. It is stated that the adhesion of the brass to the surface of the steel has been found by actual tensile test to be about fifteen tons per square inch. The core is formed with a flange through which studs holding the blade to the boss pass, and the delta metal is dove-tailed with the steel in casting in such a way as to give great strength to resist fracture through

* *Mixed Metals*, p. 115. Macmillan & Co., London. 1890.

† *Iron* (London), vol. 21, 1883, p. 159.

‡ *Trans. of the Institution of Naval Architects*, 1888, p. 371.

the stud holes in the flange. To prevent any slight galvanized action taking place between the delta metal and the steel at the line of contact on the face of the flange and in the stud holes, there is used an insulating material which can readily be applied.*

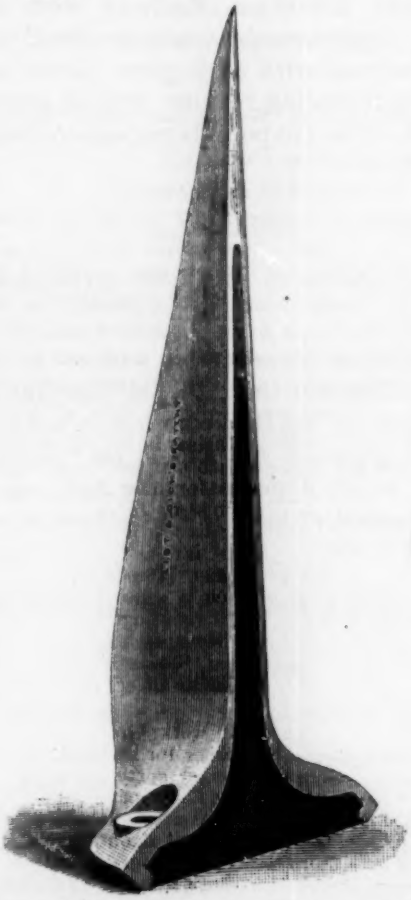


FIG. 4. Composite propeller blade of delta metal and steel.

Delta metal can be forged, stamped and rolled hot. It must be forged at a dark cherry red heat, and care taken to avoid striking when at a black heat.

* *Iron* (London), July 25, 1890, p. 72.

According to Lloyd's Proving House tests, made at Cardiff, December 20, 1887, a half-inch delta metal rolled bar gave a tensile strength of 88,400 pounds per square inch, with an elongation of thirty per cent. in three inches. The *Schweizerische Bauzeitung* states that the large worm wheels for the Pilatus Mountain Railway were cast in delta metal by the *Schweizerische Locomotivfabrik* in Winterthur. A test bar was cast with each piece, these bars were then tested with the following results: tensile strength 36·6 kgs. per square mm., or 51,520 pounds per square inch; elongation, 10·5 per cent.*

[*To be continued.*]

## RIVETED JOINTS IN BOILER-SHELLS—LE VAN.

The Publication Committee wishes to state, to the readers of the *Journal*, that Mr. Le Van has written to it, expressing regret at his inadvertence in not acknowledging the sources of parts of his article on "Riveted Joints in Boiler Shells," which appeared in the April and May impressions of this journal.

* *Engineering*, April 22, 1887, p. 382.

# PROCEEDINGS
OF THE
# CHEMICAL SECTION
OF THE
# FRANKLIN INSTITUTE.

[*Proceedings of the stated meeting, held Tuesday, May 19, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 19, 1891.

Dr. WM. H. GREENE, Vice-President, in the chair.

Sixteen members and seven visitors were present.

Dr. W. P. Mason, of the Rensselaer Polytechnic Institute, of Troy, N. Y., read a paper on, "Drinking Water and Disease." It was referred for publication. A discussion of the paper, which was of much interest, followed, and was conducted by the author and Messrs. Pemberton, Jayne and Haines.

Mr. Pemberton called attention to the conditions of the water supply of Chester and discussed the effect of Philadelphia sewage upon it.

Dr. Bruno Terne presented a paper on "Meat Preservatives," giving a discussion of the ingredients and their effects upon the human system when present in meat used as food.

The paper was discussed by the author and Mr. Haines.

Adjourned.

WM. C. DAY, *Secretary.*

## ON THE AMMONIA PROCESS OF WATER ANALYSIS.

BY REUBEN HAINES.

[*Read at the stated meeting, held April 21, 1891.*]

Two forms of this process are in use, one dealing with a half litre or a full litre of the water; the other requiring only 100 cc. for the distillation. The writer prefers the former, although some chemists find the latter fully as accurate and more convenient.

The following notes indicate the practice of the writer for a number of years, in addition to the instructions given by Wanklyn.

The amount of sample used is one-half litre, or, in some very impure waters, a less quantity of the sample diluted to half a litre with pure distilled water.

The retort is of large size, having a capacity of from one-third to one-half gallon when completely filled, and is supported at the neck by a large retort-clamp upon a heavy iron stand. It should not be supported on a ring, unless wire gauze be interposed, as otherwise there is great danger of fracture of the retort. If a Bunsen burner with wire gauze is used close up beneath the retort with such a body of liquid there is still danger of fracture.

The neck of the retort is inclined *upward* at an angle of about 25° and attached to a Liebig condenser having an inner tube of one inch diameter, by a short piece of wide rubber-tubing in such manner that the ends of the retort and condenser are in close contact and that as little rubber as possible is exposed to the action of the hot vapor. In lieu of this arrangement a few inches of the end of the retort-neck may be bent downward parallel with the condenser, and be made to enter loosely within the glass condenser tube; a short piece of rubber-tubing overlapping the connection. In either case, the rubber should be tied down to prevent leakage, but in such manner that the retort may readily be disconnected at the conclusion of the analysis. The rubber will have to be renewed after a time. The mode of connection recommended by Wanklyn has been shown by Dr. Smart, Mallet and others, to permit loss of ammonia by leakage.

A rather rapid current of water should be maintained in the Liebig condenser. If this condenser alone is used, the current should be so rapid that the temperature of the water at the exit is not materially raised by the operation if the water used has an original temperature of from 50° to 60° F. If the water is of higher temperature than this ice should be used for cooling it. A better plan is that adopted by the writer, which consists in attaching the lower end of the Liebig condenser as closely as possible to a glass vertical coil condenser of the Mohr pattern, of which the outer vessel is an inverted jar receiver (a large inverted bottle with the bottom cut off will do very well), into which broken ice may be placed, especially in hot weather. The glass tube forming the coil has an inside

diameter of about half an inch. Beneath this second condenser a short nearly horizontal tube, conducts the distillate to the Nessler glass out of reach of contaminating dust, etc., that might chance to fall from the vertical condenser.

By having the retort sufficiently large, and by inclining its neck upward all danger of the permanganate being thrown over into the condenser is avoided. Risk of fracture is greatly lessened by the use of the retort clamp, and by the rod of the stand acting as a sort of spring to moderate the shock of bumping, and the retort may thus last in frequent use for a very long time. One of mine lasted several years, but it became unavoidably weakened in time by the corrosive action of the boiling alkaline liquid. By the above-described arrangement of the condensing apparatus, the distillate may be obtained at a given uniform temperature in all analyses in order to get uniform depths of color in the Nessler testing, a precaution to which some one has called attention. The risk of loss by imperfect condensation of ammonia during regular distillation, or through the outrush of gusts of vapor produced by turbulent boiling is also avoided. The condensing tube should, on account of this latter circumstance, be of comparatively large diameter throughout its whole length. With the above arrangement I have not found any loss by imperfect condensation, if the temperature of the distillates did not exceed 60° F. If a lower temperature than this is adopted, the distillates should be allowed to stand until they acquire a uniform temperature before applying the Nessler test.

The arrangement I have adopted was suggested by reading the *Report on Water Analysis*, by Prof. Mallet, to the National Board of Health, 1882, in which this loss of ammonia occurring when Wanklyn's instructions are followed is referred to, and a somewhat different arrangement suggested for avoiding it. In experiments with a known solution of ammonium chloride this loss was found by Dr. Smart to amount to an average of about seven per cent. of the whole amount that should have been obtained. It should, however, be noted that Mallet states that "the temperature of the condensing water varied from 25° to 25°·5 C."

which is a rather high temperature. In these experiments the current of water in the condenser was so rapid that its temperature was not sensibly raised by the process, even when fifty cc. of distillate were obtained in eight minutes. The distillates of fifty cc. each are received directly into the Nessler tubes marked at fifty cc., and the earlier portions may be Nesslerized while the distillation is progressing. Wanklyn advises to Nesslerize only the first distillate of fifty cc. free $NH_3$ and add to this one-third. In waters containing enormous amounts of free ammonia, however, it is better either to distil the whole of the free ammonia into a flask in one portion, dilute, and take an aliquot part for the Nessler test, or to follow Dr. Smart's plan of Nesslerizing each successive distillate of fifty cc., previously diluting if necessary. Dr. Smart believes that the presence of urea in the water may be detected by peculiarities in the manner in which the free ammonia distils over in the successive portions. I have found that polluted waters containing enormous amounts of free ammonia such as to give a very deep color or a precipitate by the Nessler test in fifty cc. of the original sample appear to yield four-fifths or five-sixths of the whole amount in the first portion of fifty cc. instead of three-fourths, as stated by Wanklyn.

It is not advisable to put anything whatever, such as pieces of ignited pumice, tobacco pipe, etc., inside the retort to moderate the bumping, as suggested by some, there being too much danger of introducing thereby organic or ammoniacal impurity. The bumping can be controlled if necessary by lowering the flame and by tapping gently on the retort so as to produce a concentric wavy motion on the surface of the liquid, which will cause the steam to rise more regularly and in smaller bubbles. A Bunsen burner, giving a large flame, should be used. I prefer one having several jets, or a rose-burner, and place it quite close to the retort, without any intervening wire gauze.

All the apparatus used for water analysis should be set aside exclusively for this purpose. Thorough washing of each article immediately before use is very essential. To be thought "clean enough" is by no means sufficient. The

whole condensing apparatus set up ready for use, but disconnected from the retort, can be satisfactorily washed by flushing it thoroughly two or three times with clean hydrant water, closing the outlet by the finger or a clean cork until the condenser tube is full and then allowing the water to run out. This method of washing is much better than distilling some clean water through it as advised by some. The retort should be rinsed with a little concentrated sulphuric acid and washed thoroughly with clean tap water, and then immediately connected with the condenser.

The above form of apparatus may be considered by some to be cumbrous and to occupy too much space, yet I think it possesses certain real advantages which offset these objections.

The alkaline permanganate solution can readily be prepared so pure that one litre of it undiluted yields by distillation not more than 0·005 milligrammes $NH_3$ and that no more ammonia develops in it afterward if properly protected. I have been using for more than ten years solutions prepared to this degree of purity, made up in quantities of one litre, which have kept well. The preparation is accomplished by using only very good distilled water for making up the solution, and by not permitting the sticks of caustic potash (ordinary white sticks) to come in contact with any kind of organic substance in handling and weighing it out. The mixed solution is diluted to one and one-half litres and distilled in a large retort, slowly, until about 900 cc. remain, and then 50 cc. are tested with Nessler solution. If pure, the solution is transferred when cold to a litre flask and made up to the mark with perfectly pure distilled water, made free from ammonia and organic matter by distillation with some solution of alkaline permanganate of potash. I found that if river water from a hydrant was used in making the solution it was very difficult to obtain a solution perfectly free from ammonia, even after very protracted slow boiling. If an impure solution is used, and a correction applied for the impurity it contains, it will be found that the results of analysis are thereby subjected to error. I strongly suspect that errors from that cause did occur in

some of my earliest analyses many years ago. Liability to error from this cause has been noticed also by others. Wanklyn, I think, never applied a correction for impurity, but always prepared the solution free from $NH_3$, if I understand rightly a certain discussion which took place in the early history of the process. Yet Dr. Tidy, in 1879, declared the preparation of a solution of alkaline permanganate, free from ammonia, to be impossible, and said that he always had to make a correction for the ammonia he found it to contain. This was one of the several objections that were strongly urged against the ammonia process of analysis. On the other hand, Prof. Mallet states, in his Report to the National Board of Health, 1882, that Dr. Smart in the investigations for that report made up his solution with good distilled water, and after the requisite boiling "it gave no coloration with Nessler reagent in fifty cc. distilled off from one-half litre."

Care should always be taken to rinse off the stoppered mouth of the bottle containing the permanganate solution both immediately before and after use, notwithstanding it may have been carefully protected from laboratory vapors, etc.

The rate at which both the free and albuminoid ammonia is evolved often affords valuable information as to the character of the organic matter contained in the water, and therefore the details of the separate Nessler testings should be preserved for reference. If, as sometimes happens, a peculiar odor is noticeable in the free ammonia distillate it may be presumed to be due to the volatile organic matter which has passed over with the free ammonia, but which will probably not produce a reaction with the Nessler test solution and be lost to the analysis. In this case a second distillation with alkaline permanganate added at first should be made with a fresh portion of the sample, thus obtaining the total ammonia, the free and albuminoid coming over together. If the amount of total ammonia is sensibly larger than the sum of the free and albuminoid obtained in the first distillation, the difference may be assumed to be ammonia from volatile organic matter.

From my own experience during about eight years, in

which I have very frequently repeated the distillaton in the above manner, I am led to believe that the occurrence of a volatile organic substance in well waters is at least a comparatively rare circumstance. The test is, however, a useful check upon the accuracy of the analysis. The same proportions should be adhered to in the second as in the first distillation as regards the alkaline permanganate and the quantity of water operated upon.

Prof. Remsen found, however, in 1881 a striking instance of the presence of volatile organic matter, which failed to be estimated by the ordinary method of procedure in his investigations into the Water Supply of Baltimore. Soon afterwards, Mr. Chas. W. Marsh, then at Princeton, published a paper, in the *Amer. Chem. Journal*, giving a number of instances of similar nature in well and cistern waters which he had examined. The possibility of this occurrence should therefore be recognized and provision made for the estimation of the volatile organic substance.

## ANALYSIS OF AN ARTESIAN WELL WATER.

By Reuben Haines.

[*Read at the stated meeting, held April 21, 1891.*]

The well from which the water is derived, of which an analysis is here given, is situated in a closely built-up portion of Germantown. It was sunk in 1875 to the depth of 312 feet, mostly through soft rock which was probably a micaceous schist. I was informed that about half-way down a stratum was entered which carried large quantities of iron garnets, similar to those found in the surface rock and washings at Wayne Junction. At the bottom a cavity in the rock was apparently entered, for a portion of the drilling apparatus suddenly dropped, and, falling to one side, was lost and never recovered.

The rock was first struck at about eight feet from the surface of the ground. The water rose to a level of about thirteen feet below the surface, and the average flow by pumping has since been forty gallons per minute, without

lowering the water level materially. A continuous tube of plain wrought iron, about six inches in diameter, extends to within a few feet of the bottom.

The water was stated to have been originally of satisfactory character for steam purposes, although hard and unsuited to some technical uses.

In 1877, the writer made an analysis for its potable qualities with the following results:

| | *Parts in 100,000.* | |
|---|---|---|
| Free ammonia, | 0·0020 | |
| Albuminoid ammonia, | 0·0040 | |
| Chlorine, | 3·00 | |
| Total solid matter at 100° C., | 30·00 | |
| Total hardness, | 16°·8 | parts $CaCO_3$ in 100,000 by soap test. |
| Nitrates, | traces. | |
| Sulphates, | large amount. | |

The water has since that time deteriorated so much in quality that it is now seldom used, but pumped every few weeks only to keep it clear of sediment for use in case of fire. It has a strong corrosive action on the iron tube, so that after remaining in it for several weeks it becomes exceedingly thick and turbid with iron oxide. It was in this turbid condition when the writer took a sample for analysis a few months ago, and it was only partially cleared of sediment after pumping rapidly for more than an hour.

The following are the results of analysis for potability after the abundant iron oxide was allowed to settle out from which the water was decanted, but not filtered for the determination of the free and albuminoid ammonia. For the other parts of the analysis the water was filtered.

| | *Parts in 100,000.* | |
|---|---|---|
| Free ammonia, | 0·0590 | |
| Albuminoid ammonia, | 0·0060 | |
| Nitrogen in nitrates, | 0·77 | |
| Chlorine, | 3·10 | |
| Total solids dried at 120° C., | 54·50 | |
| Mineral matter, | 48·56 | |
| Organic and volatile matter by ignition, | 5·94 | |
| Temporary hardness by Hehner's method, | 10°·5 | $CaCO_3$ |
| Permanent " " " " | 15°·0 | " |
| Total " " " " | 25°·5 | " |

The following are the results of analysis of the mineral ingredients:

| | *Parts in 100,000.* | *Grains per U. S. Gal.* |
|---|---|---|
| $Na_2O$, | 7·44 | 4·341 |
| $(NH_4)_2O$, | ·09 | ·052 |
| CaO, | 7·32 | 4·269 |
| MgO, | 5·44 | 3·172 |
| $Fe_2O_3$ and $Al_2O_3$, | ·35 | ·204 |
| $SiO_2$, | 1·90 | 1·108 |
| Cl, | 3·10 | 1·808 |
| $SO_3$, | 16·86 | 9·832 |
| $N_2O_5$, | 2·97 | 1·732 |
| $CO_2$ (calculated), | 4·65 | 2·715 |
| Organic matter, $H_2O$, etc., after deducting for loss of $N_2O_5$, $CO_2$, etc., | 5·01 | 2·922 |

These constituents are probably combined in the following manner:

| | *Parts in 100,000.* | *Grains per U. S. Gal.* |
|---|---|---|
| Ammonium nitrate, | ·180 | ·105 |
| Sodium chloride, | 5·100 | 2·974 |
| Sodium nitrate, | 4·533 | 2·643 |
| Sodium sulphate, | 7·081 | 4·129 |
| Calcium sulphate, | 17·777 | 10.367 |
| Magnesium sulphate, | 3·624 | 2·113 |
| Magnesium carbonate, | 8·887 | 5·183 |
| Silica, ferric oxide, alumina, | 2·250 | 1·312 |
| Organic matter, water of hydration, etc., | 5·010 | 2·922 |
| | 54·442 | 31·748 |

The $Na_2O$ was not estimated directly but calculated from the difference between the weighed solids converted into sulphates, and the CaO and MgO calculated as sulphate together with the $SiO_2$, $Fe_2O_3$ and $Al_2O_3$.

The test for hardness was made in the first analysis by the soap solution according to Clark, and in the recent analysis by Hehner's method which is much more accurate, especially in presence of magnesium salts.

The points of interest in regard to this well water are the increase of total solids and of hardness in a deep well water, and also the fact of its being so actively corrosive of iron in the cold.

# SUPPLEMENT TO THE DETERMINATION OF THE HEAT OF EVAPORATION, ETC., OF LIQUID AMMONIA.*

By Dr. Hans von Strombeck.

[*Presented at the stated meeting of the Chemical Section, held Jan. 19, 1891.*]

In vol. cxxx, No. 780 (December, 1890), of this journal, I gave the figures and authentic proofs for the heat of evaporation, etc., of liquid ammonia. The latter agreed well enough with one another for the purpose for which those tests were made, "to prove once more that about 500 and not 900 English thermal units were the true figures for the latent heat of liquid ammonia," but they do not agree well enough if considered from the scientific point of view. I, therefore, determined the latent heat of liquid ammonia by another series of twelve tests, the results of which I give in the following:

I made the tests and the calculations in the same manner as described in the number of this paper above-mentioned, but made the following alterations:

I *weighed* the water filled into the calorimeters instead of *measuring* it.

I placed each calorimeter in a box by itself, so that they were separated by a narrow stratum (about one-half inch) of external air. By this I intended to lessen the influence of the first calorimeter on the second one, but the figures afterwards showed that this intention was fulfilled to but a limited extent.

I took as much ammonia as with safety could be put in tank *IKL*, and I made the first calorimeter *ABCD* smaller, so as to have to take less water.

I placed two thermometers in the first calorimeter, one reading from 28 to 18°, the other from 20 to 11°.

I placed an agitator in the second calorimeter. Though this makes the handling of the apparatus still more compli-

* From the laboratory of the De La Vergne Refrigerating Machine Co.

cated, the agitator cannot be dispensed with, as only in this manner the true figures of the temperature prevailing in the second calorimeter can be obtained.

I determined the influence of the external surroundings in another manner from that of the former tests. In those, I followed the method used by Regnault, which requires the simultaneous reading of three thermometers at the end of every minute. In order to be made exact, these readings require three skilled observers, whom I had not at my disposal when I made the former tests, nor at present, and I attribute the discrepancy of the figures of my former tests mostly to my having been compelled to have the readings of two thermometers made by unskilled persons. I, therefore, determined the external influence this time in the following manner, which, theoretically, is not quite as exact as the one used by Regnault, but the errors of which are within the limit of the inevitable errors of observation, as I shall show by two examples, which follow.

### DETERMINATION OF THE INFLUENCE OF THE EXTERNAL SURROUNDINGS ON THE TEMPERATURE OF THE CALORIMETERS.

I shall add to each item the figure obtained in the first test. As soon as, at the end of the test, the thermometer in the first calorimeter stops going down, the time $m$ (42′) elapsed since the commencement of the test and the temperatures indicated by the thermometer in the first calorimeter $T_m$ (14°·79), by the thermometer in the second calorimeter $\tau_m$ (22°·75), by the thermometer in the air $\vartheta_m$ (21°·10), are noted down. After $n$ minutes (10′) have elapsed, the temperatures indicated by the three thermometers $T_n$ (14°·96), $\tau_n$ (22°·38) $\vartheta_n$ (21°·06) are again noted down. From these figures the heating or cooling effect of the external surroundings on the first calorimeter $\delta$ (— 0°·221) and on the second calorimeter $\delta_1$ (0°·963) can be calculated.

(1) $\delta$: The temperature of the first calorimeter is influenced by the temperature of the air and by that of the second calorimeter. But we may neglect the influence of the latter, its temperature being only little different from

the temperature of the air. During the $n$ minutes (10′) the first calorimeter was heated up by $T_m - T_n$ degrees (— 0°·17), the difference between the average temperature of the first calorimeter

$$\frac{T_m + T_n}{2} (14°·88)$$

and the average temperature of the air

$$\frac{\vartheta_m + \vartheta_n}{2} (21°·08)$$

being — 6°·20. During the $m$ minutes (42′) the difference between the average temperature of the first calorimeter

$$\frac{T + T_m}{2} (19°·595)$$

and the average temperature of the air

$$\frac{\vartheta + \vartheta_m}{2} (21°·52)$$

having been only — 1°·925, we obtain:

$$\delta = \frac{(-0·17) \cdot 42 \cdot (-1·925)}{10 \cdot (-6·20)} = -0°·221.$$

(2) $\delta_1$: The temperature of the second calorimeter is influenced by the temperature of the air and that of the first calorimeter. During the $n$ minutes (10′) the second calorimeter was cooled down by $\tau_m - \tau_n$ degrees (0°·37), its average temperature being

$$\frac{\tau_m + \tau_n}{2} (22°·565).$$

As the average temperature of the external surroundings is expressed by the average of the mean temperatures of the first calorimeter and of the air, *i. e.*, by

$$\frac{1}{2}\left[\frac{T_m + T_n}{2} + \frac{\vartheta_m + \vartheta_n}{2}\right] = 17°·98,$$

the difference prevailing during the $n$ minutes is 22·565 — 17·98 = 4°·585. During the $m$ minutes (42′) the differ-

ence between the average temperature of the second calorimeter

$$\frac{\tau + \tau_m}{2} \; (23°{\cdot}40)$$

and the average temperature of the external surroundings

$$\tfrac{1}{2}\left[\frac{T + T_m}{2} + \frac{\vartheta + \vartheta_m}{2}\right] = 20{\cdot}558$$

having been only $23{\cdot}40 - 20{\cdot}558 = 2°{\cdot}842$, we obtain

$$\delta_1 = \frac{0{\cdot}37.42\,.\,2°{\cdot}842}{10\,.\,4{\cdot}585} = 0°{\cdot}963.$$

To make sure that the value obtained for $\delta_1$ was the true expression for the external influence on the second calorimeter, I placed the first calorimeter *ABCD* with its appurtenances in the reverse position of that in the engraving on p. 473 (this journal, December, 1890); that is to say, so that the ammonia directly evaporated into the atmosphere, and operated exactly as I did, when determining the latent heat of liquid ammonia. All changes of temperature in the second calorimeter could therefore only be caused by the influence of the temperature of the first calorimeter and of the air. Making observations and calculations as above, we obtain one value for $\delta_1 = \tau - \tau_m$ indicated by the thermometer, another value by calculation. If the letters have the same meaning as indicated, and the observations give:

| | 1. | 2. |
|---|---|---|
| $m$, | 35′ | 30′ |
| $\frac{T + T_m}{2}$, | 18°·99 | 19°·30 |
| $\frac{\vartheta + \vartheta_m}{2}$, | 20°·03 | 20°·96 |
| $\frac{T_m + T_n}{2}$, | 13°·81 | 14°·20 |
| $\frac{\vartheta_m + \vartheta_n}{2}$, | 20°·08 | 20°·57 |
| $\tau$, | 22°·54 | 23°·82 |
| $\tau_m$, | 22°·23 | 23°·33 |

| | 1. | 2. |
|---|---|---|
| $\frac{\tau + \tau_m}{2}$, | 22°·385 | 23°·575 |
| $n$, | 10′ | 10′ |
| $\tau_m$, | 22° 08 | 23°·06 |
| $\tau_m - \tau_n$, | 0°·15 | 0°·27 |
| $\frac{\tau_m + \tau_n}{2}$, | 22°·155 | 23°·195 |
| we have $\vartheta_1$ by observation, | 0°·31 | 0° 49 |
| we have $\vartheta_1$ by calculation, | 0°·289 | 0° 470 |

If, in the following table,

$\mu$ = the weight of the first calorimeter and its appurtenances;

$\sigma$ = the specific heat of the metal (brass) of which it was made;

$\mu\sigma$ = its value in water;

$\mu_1 \sigma_1$ = the value in water of the two thermometers;

$\omega$ = the weight of the water filled into the first calorimeter;

$M = \omega + \mu\sigma + \mu_1 \sigma_1$;

$\phi T$ = the tension of the ammonia vapor at $T°$;

$\phi T_m$ = the tension of the ammonia vapor at $T_m°$;

$\phi \frac{T + T_m}{2}$ = the tension of the ammonia vapor at $\frac{T + T_m}{2}$;

$m$ = the number of minutes which the test lasted.

$T$ = the temperature of the first calorimeter at the commencement of the test;

$T_m$ = the temperature of the first calorimeter at the end of the test;

$\frac{T + T_m}{2}$ = the average of both temperatures;

$\vartheta$ = the temperature of the air at the commencement of the test;

$\vartheta_m$ = the temperature of the air at the end of the test;

$\frac{\vartheta + \vartheta_m}{2}$ = the average of both temperatures;

$n$ = the number of minutes during which observations were made for the determination of $\delta$ and $\delta_1$, respectively;

$T_n$ = the temperature of the first calorimeter at the end of the $n$ minutes;

$T_m - T_n$ = the fraction of a degree by which the temperature of the first calorimeter changed during the $n$ minutes;

$\frac{T_m + T_n}{2}$ = the average of both temperatures;

$\vartheta_n$ = the temperature of the air at the end of the $n$ minutes;

$\frac{\vartheta_m + \vartheta_n}{2}$ = the average of both temperatures;

$\delta$ = the fraction of a degree which is to be added to or subtracted from $T_m$ so as to obtain the temperature:

$T_m + \delta$ which the first calorimeter would have had if no external influence had taken place;

$T - (T_m + \delta)$ = the corrected number of degrees by which the first calorimeter was cooled down;

$M[T - (T_m + \delta)]$ = the loss of heat undergone by the first calorimeter;

$\mu_2$ = the weight of the second calorimeter and its appurtenances;

$\mu_2 \sigma$ = its value in water;

$\mu_3 \sigma_3$ = the value in water of the thermometer;

$\omega_1$ = the weight of water filled into the second calorimeter;

$M_1 = \omega_1 + \mu_2 \sigma + \mu_3 \sigma_3$;

$\tau$ = the temperature of the second calorimeter at the commencement of the test;

$\tau_m$ = the temperature of the second calorimeter at the end of the test;

$\frac{\tau + \tau_m}{2}$ = the average of both temperatures;

$\tau_n$ = the temperature of the second calorimeter at the end of the $n$ minutes;

$\tau_m - \tau_n$ = the fraction of a degree by which the temperature of the second calorimeter changed during the $n$ minutes;

$\frac{\tau_m + \tau_n}{2}$ = the average of both temperatures;

$\delta_1$ = the number of degrees which is to be added to $\tau_m$ so as to obtain the temperature:

$\tau_m + \delta_1$ which the second calorimeter would have had if no external influence had taken place;

$\tau - (\tau_m + \delta_1)$ = the corrected number of degrees by which the second calorimeter was cooled down;

$M_1 [\tau - (\tau_m + \delta)]$ = the loss of heat undergone by the second calorimeter;

$\frac{T + T_m}{2} - \frac{\tau + \tau_m}{2}$ = the difference between the average temperatures of both calorimeters;

and if the other letters have the same meaning as in my first article on this matter, we obtain from the tests and by calculation the figures given in the accompanying table:

## °C., OF LIQUID AMMONIA.

| | | 11. | 12. | Average. |
|---|---|---|---|---|
| $P$, . . | °5 | 142°2 | 145°9 | |
| $P$ — | °1 | 0°1 | 0°1 | |
| $P_1$, . | °4 | 142°1 | 145°8 | |
| $\mu$, . . | | | | |
| $\sigma$, . . | | | | |
| $\mu\sigma$, . | | | | |
| $\mu_1\sigma_1$, | | | | |
| $\omega$, . . | °0 | 3728°0 | 3715°0 | |
| $dI$, . | | | | |

$\tau_m$ = the temperature of the second calorimeter at the end of the test;

$\frac{\tau + \tau_m}{2}$ = the average of both temperatures;

$\tau_n$ = the temperature of the second calorimeter at the end of the $n$ minutes;

$\tau_m - \tau_n$ = the fraction of a degree by which the temperature of the second calorimeter changed during the $n$ minutes;

$\frac{\tau_m + \tau_n}{2}$ = the average of both temperatures;

$\delta_1$ = the number of degrees which is to be added to $\tau_m$ so as to obtain the temperature:

$\tau_m + \delta_1$ which the second calorimeter would have had if no external influence had taken place;

$-(\tau_m + \delta_1)$ = the corrected number of degrees by which the second calorimeter was cooled down;

$-(\tau_m + \delta)]$ = the loss of heat undergone by the second calorimeter;

$-\frac{\tau + \tau_m}{2}$ = the difference between the average temperatures of both calorimeters;

ne other letters have the same meaning as in my icle on this matter, we obtain from the tests and by tion the figures given in the accompanying table:



| | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|
| $P$, | 136·5 grs. | 136·7 | 134·0 | 142·5 | 142 |
| $P - P_1$, | 0·1 grs. | 0·1 | 0·1 | 0·1 | 0 |
| $P_1$, | 136·4 grs. | 136·6 | 133·9 | 142·4 | 142 |
| $\mu$, | 3516·0 grs | } These values are the same in all 12 tests. | | | |
| $\sigma$, | 0·0939 | | | | |
| $\mu\sigma$, | 330·1 grs. | | | | |
| $\mu_1\sigma_1$, | 10·0 grs. | | | | |
| $\omega$, | 3694·0 grs. | 3709·0 | 3690·0 | 3715·0 | 372 |
| $M$, | 4034·1 grs. | 4049·1 | 4030·1 | 4055·1 | 406 |
| $\phi T$, | 7448 mm. | 7184 | 7198 | 7842 | 804 |
| $\phi T_m$, | 5446 mm. | 5297 | 5271 | 4200 | 581 |
| $\phi \frac{T + T_m}{2}$ | 6388 mm. | 6166 | 6177 | 6692 | 686 |
| $f$, | 5872 mm. | 5859 | 6158 | 6254 | 645 |
| $T_0$, | 16°·98 | 16·92 | 18·43 | 18·92 | 1 |
| $m$, | 42′ | 33 | 35 | 35 | 3 |
| $T$, | 24°·40 | 23·26 | 23·27 | 26·04 | 2 |
| $T_m$, | 14°·79 | 13·68 | 13·78 | 15·97 | 1 |
| $\frac{T + T_m}{2}$ | 19°·595 | 18·47 | 18·52 | 21·00 | 2 |
| $\vartheta$, | 21°·94 | 22·25 | 20·20 | 21·20 | 2 |
| $\vartheta_m$, | 21°·10 | 21·75 | 19·61 | 20·70 | 2 |
| $\frac{\vartheta + \vartheta_m}{2}$ | 21°·52 | 22·00 | 19·90 | 20·95 | 2 |
| $n$, | 10′ | 10 | 15 | 10 | 1 |
| $T_n$, | 14°·96 | 13·89 | 14·03 | 16·12 | 1 |
| $T_m - T_n$ | −0°·17 | −0·21 | −0·25 | −0·15 | − |
| $\frac{T_m + T_n}{2}$ | 14°·88 | 13·78 | 13·90 | 16·04 | 1 |
| $\vartheta_n$, | 21°·06 | 21·75 | 21·30 | 20·56 | 2 |
| $\frac{\vartheta_m + \vartheta_n}{2}$ | 21°·08 | 21·75 | 19·50 | 20·63 | 2 |
| $\delta$, | −0°·221 | −0·307 | −0·143 | 0·005 | |
| $T_0 + \delta$, | 14°·569 | 13·73 | 13·637 | 15·975 | 1 |
| $T - (T_m + \delta)$, | −9°·831 | −9·887 | −9·633 | −10·065 | − |
| $M[T - (T_m + \delta)]$, | −39659·2 C. | −40033·5 | −38821·0 | −40814·6 | −410 |
| $k$, | 317·4 | } | | | |
| $c$, | 0·5084 | | | | |
| $l$, | 1·22876 | | | | |
| $\mu_2$ | 1643·0 grs. | } These values are the same in all 12 tests. | | | |
| $\sigma_2$ | 0·0939 | | | | |
| $\mu_2\sigma_2$, | 154·3 grs. | | | | |
| $\mu_3\sigma_3$, | 5·0 grs. | | | | |
| $\gamma_1$, | −1°·453 | } | | | |
| $\omega_1$, | 588·0 grs. | 598·0 | 606·0 | 595·0 | 5 |
| $M_1$, | 747·3 grs. | 757·3 | 765·3 | 754·3 | 7 |
| $\tau$, | 24°·05 | 23·15 | 22·94 | 25·10 | |
| $\tau_m$, | 22°·75 | 22·30 | 21·84 | 23·76 | |
| $\frac{\tau + \tau_m}{2}$ | 23°·40 | 22·72 | 22·37 | 24·43 | |
| $\tau_n$, | 22°·38 | 22·00 | 21·30 | 23·37 | |
| $\tau_m - \tau_n$, | 0°·37 | 0·30 | 0·51 | 0·39 | |
| $\frac{\tau_m + \tau_n}{2}$ | 22°·565 | 22·15 | 21·55 | 23·56 | |
| $\delta_1$, | 0°·963 | 0·561 | 0·775 | 0·903 | |
| $\tau_m + \delta_1$, | 23°·713 | 22·861 | 22·585 | 24·663 | |
| $\tau - (\tau_m + \delta_1)$, | −0°·337 | −0·289 | −0·355 | −0·437 | − |
| $M_1[\tau - (\tau_m + \delta_1)]$, | −251·8 C. | −218·9 | −271·7 | −329·6 | − |
| $\frac{T + T_m}{2} - \frac{\tau + \tau_m}{2}$ | −3°·80 | −4·25 | −3·85 | −3·43 | − |
| $M_1[\tau - (\tau_m + \delta_1)] + Pc\left[\frac{T + T_m}{2} - \frac{\tau + \tau_m}{2}\right]$ | −515·5 C. | −514·2 | −533·9 | −577·9 | − |
| $M[T - (T_m + \delta)] + M_1[\tau - (\tau_m + \delta_1)]$, | −39911·0 C. | −40252·4 | −39093·7 | −41144·2 | −41 |
| $s$, | 0·02 C. | 0·006 | 0·02 | 0·05 | |
| $q_1$, | −4·7 C. | −4·6 | −4·6 | −4·7 | − |
| $s_1$, | −263·3 C. | −294·9 | −262·2 | −248·3 | − |
| $s_2$, | −804·5 C. | −802·8 | −781·8 | −882·5 | − |
| $q_2$, | −439·2 C. | −259·8 | −14·8 | −364·2 | − |
| $Q$, | −40886·7 C. | −41015·5 | −39622·5 | −42137·9 | −42 |
| $\lambda = \frac{Q}{P}$ | −299·6 C. | −300·0 | −295·7 | −295·7 | − |
| $q = q_2/P$, | −3·2 C. | −1·9 | −0·1 | −2·5 | |
| $r = \frac{Q - q}{P}$ | −296·4 C. | −298·1 | −295·6 | −293·2 | − |

## ERMINATION OF THE HEAT OF EVAPORATION, ETC., OF LIQUID AMMONIA.

| 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | Average. |
|---|---|---|---|---|---|---|---|---|
| 142°7 | 135°5 | 144°6 | 143°4 | 141°7 | 140°5 | 142°2 | 145°9 | |
| 0°1 | 0°1 | 0°1 | 0°1 | 0°1 | 0°1 | 0°1 | 0°1 | |
| 142°6 | 135°4 | 144°5 | 143°3 | 141°6 | 140°4 | 142°1 | 145°8 | |
| | | | | | | | | |
| | | | | | | | | |
| 3721°0 | 3728°0 | 3725°0 | 3731°0 | 3752°0 | 3722°0 | 3728°0 | 3715°0 | |
| 4061°1 | 4068°1 | 4065.1 | 4071°1 | 4092°1 | 4061°1 | 4068°1 | 4055°1 | |
| 8044 | 7836 | 7596 | 7514 | 7229 | 7314 | 7287 | 7219 | |
| 5813 | 5776 | 5448 | 5375 | 5216 | 5296 | 5247 | 5150 | |
| 6861 | 6757 | 6456 | 6269 | 6810 | 6244 | 6197 | 6119 | 6428 mm. or 124°5 lbs. absol. press. |
| 6458 | 6358 | 5816 | 6135 | 5552 | 5526 | 6169 | 6009 | 6018 mm. or 115°7 lbs. absol. press. |
| 19°95 | 19°45 | 16°70 | 18°11 | 15°37 | 15°24 | 18°49 | 17°68 | 17°·69 Cels. or 63°·84 Fahr. |
| 38 | 36 | 40 | 37 | 37 | 34 | 36 | 42 | |
| 26°85 | 26°10 | 25°06 | 24°70 | 23°42 | 23°80 | 23°68 | 23°38 | |
| 16°69 | 16°50 | 14°82 | 14°40 | 13°48 | 13°94 | 13°60 | 13°10 | |
| 21°77 | 21°30 | 19°94 | 19°55 | 18°45 | 18°87 | 18°64 | 18°24 | 19°·53 Cels. or 67°·15 Fahr. |
| 21°20 | 21°52 | 20°25 | 20°50 | 19°48 | 21°40 | 20°00 | 20°64 | |
| 21°40 | 21°00 | 20°69 | 20°30 | 19°08 | 20°66 | 19°40 | 19°90 | |
| 21°30 | 21°26 | 20°47 | 20°40 | 19°28 | 21°03 | 19°70 | 20°27 | |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | |
| 16°81 | 16°62 | 15°00 | 14°52 | 13°64 | 14°12 | 13°76 | 13°30 | |
| — 0°12 | — 0°12 | — 0°18 | — 0°12 | — 0°16 | — 0°18 | — 0°16 | — 0°20 | |
| 16°75 | 16°56 | 14°91 | 14°46 | 13°56 | 14°03 | 13°68 | 13°20 | |
| 21°10 | 20°88 | 20°73 | 20°12 | 19°30 | 20°52 | 19°30 | 19°80 | |
| 21°25 | 20°94 | 20°71 | 20°21 | 19°19 | 20°59 | 19°35 | 19°85 | |
| 0°048 | 0°004 | — 0°066 | — 0°065 | — 0°087 | — 0°201 | — 0°108 | — 0°258 | |
| 16°738 | 16°504 | 14°754 | 14°335 | 13°393 | 13°739 | 13°492 | 12°842 | |
| — 10°112 | — 9°596 | — 10°306 | — 10°365 | — 10°027 | — 10°061 | — 10°188 | — 10°538 | |
| — 41064°8 | — 39937°5 | — 41894°9 | — 42106°9 | — 41031°5 | — 40868°6 | — 41445°8 | — 42732°7 | |
| | | | | | | | | |
| | | | | | | | | |
| 585°0 | 596°0 | 608°0 | 604°0 | 599°0 | 603°0 | 592°0 | 602°0 | |
| 744°3 | 755°3 | 767°3 | 763°3 | 758°3 | 762°3 | 751°3 | 761°3 | |
| 25°91 | 25°32 | 23°99 | 23°80 | 22°88 | 23°43 | 23°20 | 23°10 | |
| 24°34 | 24°08 | 22°83 | 22°50 | 21°64 | 22°33 | 21°88 | 21°76 | |
| 25°12 | 24°70 | 23°41 | 23°15 | 22°26 | 22°88 | 22°54 | 22°43 | |
| 23°93 | 23°74 | 22°53 | 22°12 | 21°26 | 21°93 | 21°48 | 21°38 | |
| 0°41 | 0°34 | 0°30 | 0°38 | 0°38 | 0°40 | 0°40 | 0°38 | |
| 24°13 | 23°91 | 22°68 | 22°31 | 21°45 | 22°13 | 21°68 | 21°57 | |
| 1°090 | 0°809 | 0°788 | 0°898 | 0°941 | 0°827 | 0°939 | 1°005 | |
| 25°43 | 24°889 | 23°618 | 23°398 | 22°581 | 23°157 | 22°819 | 22°765 | |
| — 0°480 | — 0°431 | — 0°372 | — 0°402 | — 0°299 | — 0°273 | — 0°381 | — 0°335 | |
| — 357°3 | — 325°5 | — 285°4 | — 306°8 | — 226°7 | — 208°1 | — 286°2 | — 258°0 | |
| — 3°35 | — 3°40 | — 3°47 | — 3°60 | — 3°81 | — 4°01 | — 3°90 | — 4°19 | |
| — 600°2 | — 559°8 | — 540°4 | — 569°2 | — 501°0 | — 494°4 | — 568°2 | — 565°7 | |
| — 41422°1 | — 39363°0 | — 42180°3 | — 42503°7 | — 41258°2 | — 41076°9 | — 41732°0 | — 42987°7 | |
| 0°05 | 0°04 | 0°06 | 0°05 | 0°03 | 0°02 | 0°02 | 0°01 | |
| — 4°7 | — 4°7 | — 4°7 | — 4°7 | — 4°6 | — 4°6 | — 4°6 | — 4°7 | |
| — 242°9 | — 234°2 | — 255°0 | — 262°4 | — 274°3 | — 286°3 | — 282°0 | — 310°7 | |
| — 890°2 | — 799°2 | — 908°3 | — 907°4 | — 864°8 | — 850°9 | — 880°5 | — 908°8 | |
| — 318°9 | — 308°0 | — 574°8 | — 253°7 | — 535°9 | — 626°4 | — 26°2 | — 99°1 | |
| — 42383°6 | — 40231°2 | — 43403°7 | — 43397°7 | — 42380°0 | — 42263°3 | — 42352°1 | — 43680°2 | |
| — 297°0 | — 296°9 | — 300°2 | — 302°6 | — 299°1 | — 300°8 | — 297°8 | — 299°3 | — 298°7 French or — 537°7 English thermal units. |
| — 2°2 | — 2°3 | — 3°9 | — 1°8 | — 3°1 | — 4°4 | — 0°2 | — 0°7 | — 2°2 French or — 4°0 English thermal units. |
| — 294°8 | — 294°6 | — 296°3 | — 300°8 | — 296°0 | — 296°4 | — 297°6 | — 298°6 | — 296°5 French or — 533°7 English thermal units. |

# On the Heat of Formation of Fluorides.

By Jos. W. Richards.

[*Read at the meeting of the Chemical Section, held April 21, 1891.*]

Until the heat of formation of some fluorine compound from its elements was known, it was manifestly impossible to determine the heat of formation of the fluorides. On the other hand, as soon as the heat of formation of any fluorine compound had been determined, that of any other fluorine compound could be deduced from this by the calorimetric measurement of a double reaction, in which the first compound took part and the second was produced. Many data of this latter kind had been accumulated before the fundamental datum of the first kind was obtained, for the simple reason that free fluorine is required in order to determine primarily the heat of formation of a fluorine compound, while the double reactions referred to above only investigate the thermal differences between various fluorine compounds, and so do not require free fluorine.

Guntz, in 1883,* published some data which he miscalled "Heats of Formation of Fluorides." Under this caption he gives the following figures:

| | | |
|---|---|---|
| Potassium fluoride, | . . . . . | 38·2 cal. |
| Sodium " | . . . . . | 39·9 " |
| Barium " | . . . . . | 35·7 " |
| Strontium " | . . . . . | 35·9 " |
| Calcium " | . . . . . | 33·3 " |
| Ammonium " | . . . . . | 37·3 " |

The writer knows of at least one well-educated chemist who was misled by the manner in which Guntz gives these figures, into quoting 39·9 calories as the real heat of formation of sodium fluoride. However, on examining Guntz's paper in detail, we find that he neutralized the metallic hydrates in solution by aqueous hydrofluoric acid, and having determined the collateral data—the heat of solution

* *Comptes Rendus*, **97**, 1483, 1558; **98**, 816.

of the hydrates, fluorides and hydrofluoric acid—he calculated the heat which would be developed if gaseous hydrofluoric acid acted on the solid hydrates, forming solid fluorides and solid water. These numbers he called the heats of formation of these fluorides, and they are the numbers given above.

In 1884,* Guntz published a memoir on "Thermal Researches on the Combinations of Fluorine with Metals," in which he gives the heats of neutralization of the hydrates of potassium, sodium, ammonium, calcium, strontium, barium, magnesium, lead and silver, in aqueous solution by hydrofluoric acid. He also gives the heats of solution in water of the fluorides of potassium, sodium, ammonium, silver and antimony (the others being insoluble), and of gaseous and liquid hydrofluoric acid. With these data, it was possible for Guntz to calculate the absolute heat of formation of the above fluorides, expressing them as a certain excess above the heat of formation of gaseous hydrofluoric acid, which was an unknown quantity in all the equations. His results were as follows (calling the unknown quantity, [H, F], X):

$$R\ (solid) + F\ (gas) = RF\ (solid)$$

| | | |
|---|---|---|
| Potassium, | KF | 71·7 + X cal. |
| Sodium, | NaF | 71·8 + X " |
| Calcium, | ½ ($CaF^2$) | 74·3 + X " |
| Strontium, | ½ ($SrF^2$) | 71·0 + X " |
| Magnesium, | ½ ($MgF^2$) | 67·2 + X " |
| Lead, | ½ ($PbF^2$) | 15·1 + X " |
| Silver, | AgF | −11·9 + X " |
| Antimony, | ⅓ ($SbF^3$) | 8·5 + X " |
| Silicon, | ¼ ($SiF^4$) | 29·9 + X " |

Guntz even went so far as to make a guess as to what the value X might be, with a somewhat remarkable result. He argued that since chlorine gas does not decompose anhydrous potassium fluoride, the heat of formation of the latter must be superior to that of potassium chloride, which is 105·0 calories. Further, if the difference between these two numbers is assumed to be similar to that between the

* *Annales de Chimie et de Physique*, [vi], **3**, 5.

heats of formation of potassium chloride and bromide, we may add this difference to 105·0 calories, and call the result the heat of formation of potassium fluoride, which can then be placed equal to 71·7 + X, and X evaluated. Guntz here makes two serious and almost incomprehensible blunders. There is absolutely no warrant for the above assumption, and it could be true only by the merest accident. Further, Guntz assumes the difference spoken of as 4·6 calories. Where this number comes from is incomprehensible, for the difference derived from Thomsen's data is 10·3, and the source of the number 4·6 is veiled in mystery. However, using this number, the value of X found was 37·5 calories. That this number was the true one could be possible only by the greatest chance, as it rested on a false assumption and the use of a wrong datum, yet by a strange fortuity this number is only 0·1 calorie from the direct determination made five years later. Guntz deserves much credit for the work he did, but he can hardly claim any renown from this prediction.

Two years later,* Moissan isolated fluorine, and found that it decomposed solid potassium chloride in the cold, disengaging chlorine, thus making it probable in a high degree that the heat of formation of potassium fluoride was greater than that of the chloride, that therefore 71·7 + X calories was greater than 105·6, and consequently X greater than 33·9 calories.

In 1889,† Berthelot and Moissan succeeded in determining, experimentally, the heat of formation of hydrofluoric acid. They found:

$$H\ (gas) + F\ (gas) = HF\ (gas) + 37{\cdot}6\ \text{calories.}$$

This was the key which unlocked the question of the heats of formation of the fluorides, for since Guntz had determined the heat of solution of hydrofluoric acid gas in water as 11·8 calories, the heat of formation of the fluorides in aqueous solution could then be calculated from the heats

* *Comptes Rendus*, **102**, 1543.

† *Idem*, **109**, 209.

of neutralization of the metallic hydrates by aqueous hydrofluoric acid.

In 1889 and 1890,* E. Petersen, of Copenhagen, did good service in the line we are considering, by determining the heats of neutralization of most of the metallic hydrates by hydrofluoric acid.

The following table gives the data obtained by Guntz and Petersen:

| | HEAT EVOLVED BY THE REACTION Q+2 HF aq. | |
|---|---|---|
| *Q.* | *Guntz.* | *Petersen.* |
| $2LiOHaq$, | — | 32·80 cal. |
| $2KOHaq$, | 32·30 cal. | 32·20 " |
| $2NaOHaq$, | 32·60 " | §32·54 " |
| $2TlOHaq$, | — " | 32·90 " |
| $2NH^4OHaq$, | 30·40 " | — |
| $Ba(OH)^2aq$, | *34·80 " | 32·30 " |
| $Sr(OH)^2aq$, | *35·80 " | 35·47 " |
| $Ca(OH)^2aq$, | *17·26 " | 36·31 " |
| $Mg(OH)^2$, | †30·40 " | 30·12 " |
| $Be(OH)^2$, | — | 19·68 " |
| $Mn(OH)^2$, | — | 25·10 " |
| $Zn(OH)^2$, | — | 25·10 " |
| $Cd(OH)^2$, | — | 25·56 " |
| $Fe(OH)^2$, | — | 26·53 " |
| $Co(OH)^2$, | — | 26·49 " |
| $Ni(OH)^2$, | — | 27·67 " |
| $Cu(OH)^2$, | — | 20·17 " |
| $PbO$, | *22·2 " | — |
| $Ag^2O$, | 14·6 " | — |
| $\frac{1}{3}Fe^2(OH)^6$, | — | 15·83 " |
| $\frac{1}{3}Al^2(OH)^6$, | — | 23·42 " |
| $\frac{1}{3}Cr^2(OH)^6$, | — | 16·78 " |
| $\frac{1}{3}Mn^2(OH)^6$, | — | 17·21 " |
| $\frac{1}{3}V^2(OH)^6$, | — | 17·41 " |
| $\frac{1}{4}SiO^2aq$, | †11·3 " | — |
| $\frac{1}{3}B^2O^3aq$, | ‡9·2 " | — |
| $\frac{1}{3}Sb^2O^3aq$, | 10·1 " | — |

* Resulting fluoride precipitated.

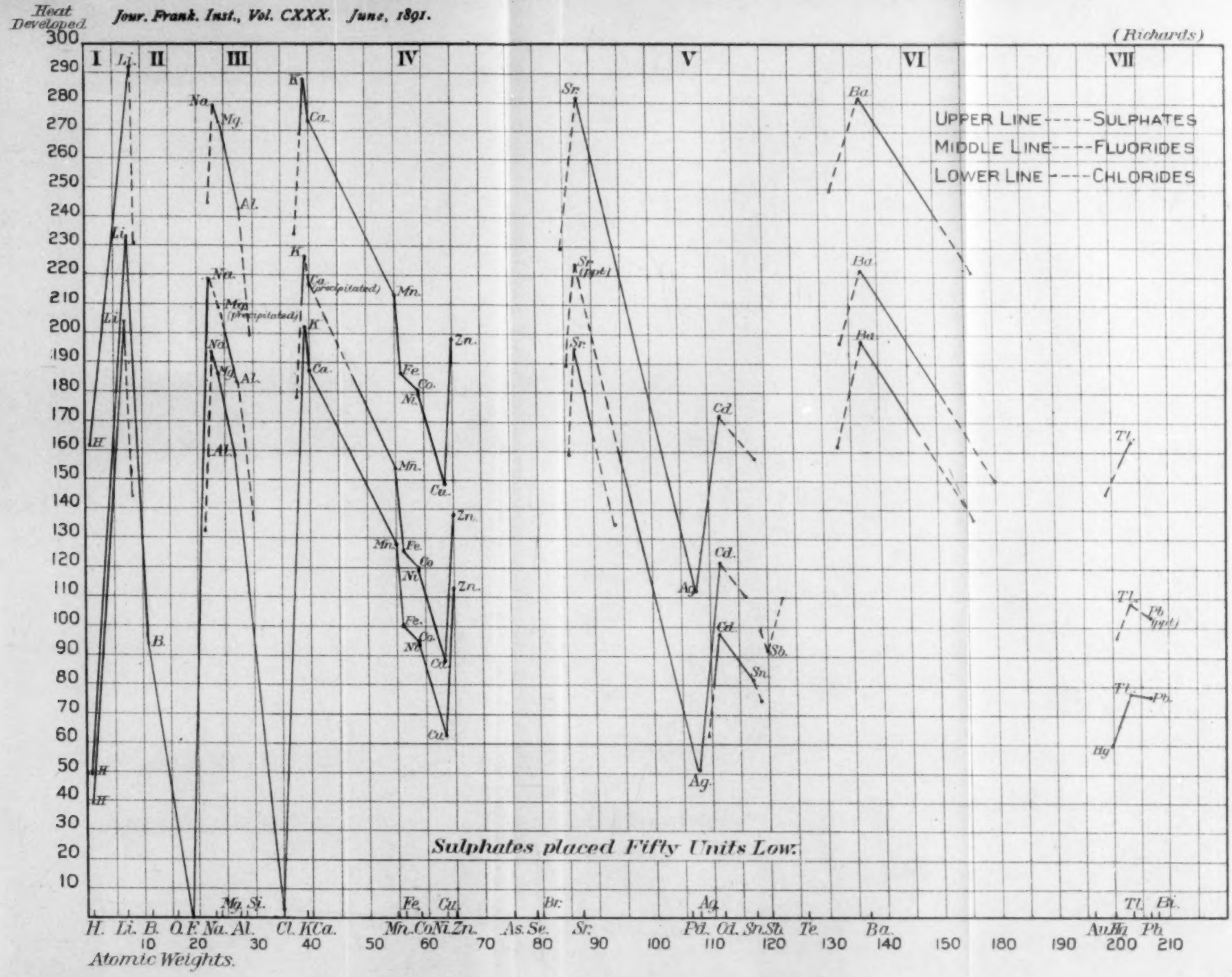
† An excess of acid, 8 HF, had to be used, forming a fluorhydrate.

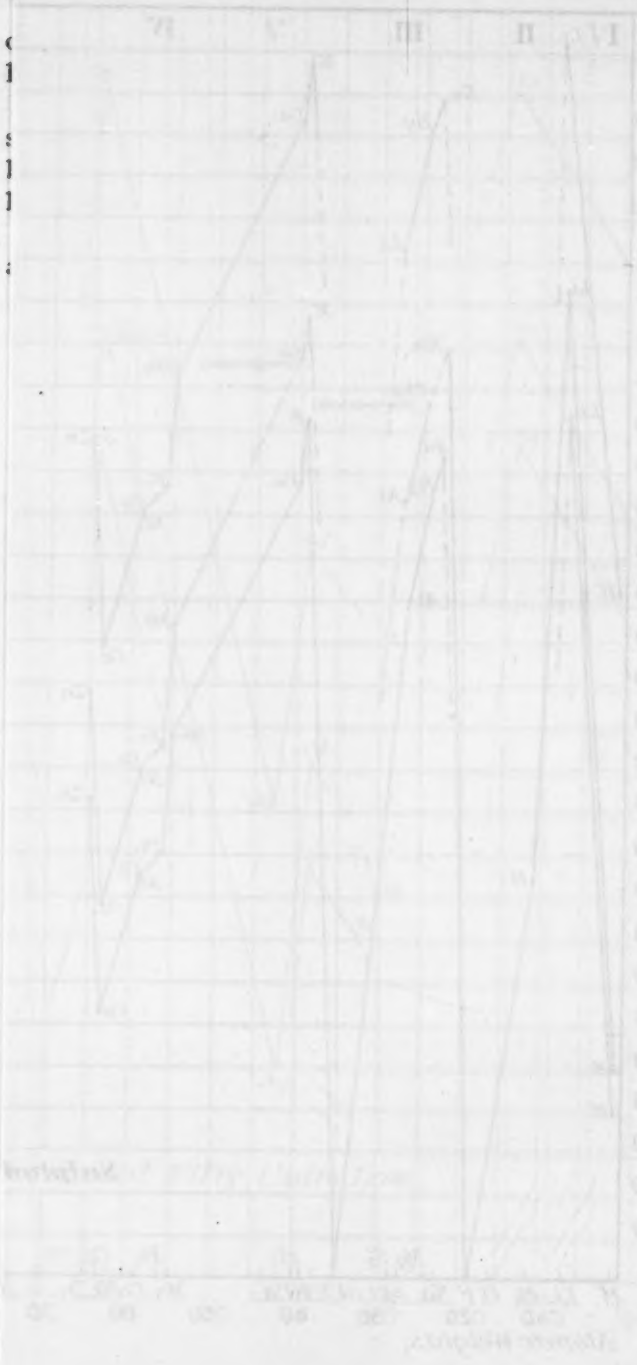
‡ Determined by Thomsen.

§ Thomsen found the same value.

In order to use these data correctly, we must notice the

* *Zeitschrift für physikalische Chemie*, **4**, 385; **5**, 258.


Heat Developed
(Richards)
I
II
III
IV
V
VI
VII
UPPER LINE-----SULPHATES
MIDDLE LINE----FLUORIDES
LOWER LINE ----CHLORIDES
Sulphates placed Fifty Units Low.
H. Li. B. O. F. Na. Al. Cl. K Ca. Mn. Co Ni Zn. As. Se. Sr. Pd. Cd. Sn. Sb. Te. Ba. Au Hg Pb
Atomic Weights.



fact of the insolubility of some of the fluorides. Petersen found that by working with very dilute solutions all the fluorides he tried were soluble excepting those of strontium, calcium, magnesium and lead. Guntz, for instance, found barium fluoride nearly insoluble, and gave his value as a close approximation to that for precipitated barium fluoride, while Petersen dissolved it in a large excess of water and obtained a result 2·50 calories lower, showing the heat of solution of barium fluoride to be close to or a little less than 2·50 calories. The heats of solution of the following fluorides have been determined:

| | | |
|---|---|---|
| Potassium fluoride, | + 3·6 cal. | Per formula weight of salt dissolved. |
| Sodium " | — 0·6 " | |
| Ammonium " | — 1·5 " | |
| Silver " | + 3·4 " | |
| Antimony " | — 4·0 " | |

For the above fluorides, then, we can calculate their heats of formation anhydrous as well as in aqueous solution. We can do this, approximately, for barium fluoride also. For the insoluble fluorides their heat of formation in the solid state only can be found. For all the other fluorides we can calculate only their heat of formation in aqueous solution, and this only when we know the heat of formation of the metallic hydrate to start with. This latter factor is not known with respect to beryllium, chromic, manganic and vanadic hydrates.

Starting with the data thus presented, the writer has calculated the heats of formation of those fluorides for which there is sufficient data, using generally the heats of formation of the hydrates as given by Thomsen.

HEATS OF FORMATION OF FLUORIDES.

| *M.* | *Products Solid.* $[MF^2]$ | *Heat of Solution.* $[MF^2, aq]$ | *Products Dissolved.* $[MF^2, aq]$ |
|---|---|---|---|
| $Li^2$, | — | — | 233·76 |
| $K^2$, | 220·00 | + 7·20 | 227.20 |
| $Na^2$, | 219·44 | — 1·20 | 218·24 |
| $Tl^2$, | — | — | 108·81 |
| $[NH_4]^2$, | 202·50 | —3·00 | 199·50 |
| Ba, | 224·00 | —2·50 | 221·50 |
| Sr, | 224·02 | — | — |

HEATS OF FORMATION OF FLUORIDES.—(*Continued.*)

| *M.* | *Products Solid.* $[MF^2]$ | *Heat of Solution.* $[MF^2, aq]$ | *Products Dissolved.* $[MF^2, aq]$ |
|---|---|---|---|
| Ca, | 216·90* / 216·00† | — | — |
| Mg, | 209·50 | — | — |
| Mn, | — | — | 153·31 |
| Zn, | — | — | 138·22 |
| Cd, | — | — | 121·72 |
| Fe, | — | — | 125·22 |
| Co, | — | — | 120·34 |
| Ni, | — | — | 118·98 |
| Cu, | — | — | 88·16 |
| Pb, | 100·71* / 102·50* | | |
| $Ag^2$ | 44·14 | + 6·8 | 50·94 |
| $\frac{1}{3}F^2$, | — | — | 109·96 |
| $\frac{1}{3}Al^2$, | — | — | 183·48 |
| $\frac{1}{2}Si$, | 137·96 | — | — |
| $\frac{1}{3}Sb^2$, | 92·79 | — 1·67 | 91·12 |
| $\frac{1}{3}B^2$, | — | — | 146·23 |

* Based on Guntz's experiment.

† Based on Petersen's experiment.

In the large diagram accompanying this paper, I have used the atomic weights of the elements as abscissas, and the heat of formation of their fluorides in aqueous solution as ordinates. The resultant connecting line, though fragmentary, shows very clearly the periodic variation of these heats of formation with the increase of atomic weight, dividing the elements into seven families corresponding to the seven families of the well-known classification of the elements by the Periodic Law. Mr. A. P. Laurie, in 1883,* arranged the chlorides in this way, and I have placed the chloride line on the diagram as well as the line of the sulphates (the latter brought down fifty units for convenience in drawing the chart). An inspection of the diagram shows a very near approach to parallelism in these three lines, the variations being hardly perceptible on the chart; but, if we tabulate the numerical differences between the heats of formation of these three classes of compounds, we will discern the irregularities more easily. We will only com-

* *Philosophical Magazine*, **15**, 41.

pare those elements for which we know the heats of formation of the three salts, all in aqueous solution with the exception of those marked with a star.

| *M.* | CHLORIDES FROM FLUORIDES. $[MF^2, aq] - [MCl^2, aq]$ | *Deviation from mean difference.* | FLUORIDES FROM SULPHATES. $[MSO^4, aq] - [MF^2, aq]$ | *Deviation from mean difference.* |
|---|---|---|---|---|
| $Li^2$, | 29·36 | + 4·17 | 106·56 | — 3·92 |
| $K^2$, | 24·99 | — 0·20 | 111·22 | + 0·74 |
| $Na^2$, | 25·22 | + 0·03 | 111·21 | + 0·73 |
| Ba, | 24·69 | — 0·50 | 110·98 | + 0·50 |
| Sr, | *28·03 | + 2·84 | *106·90 | — 3·58 |
| Ca, | *28·77 | + 3·58 | *106·55 | — 3·92 |
| Mg, | *22·57 | — 2·62 | *113·16 | + 2·68 |
| $\frac{1}{3}Al^2$, | 24·93 | — 0·26 | 109·57 | — 0·91 |
| $\frac{1}{3}Fe^2$, | 24·81 | — 0·38 | — | — |
| Mn, | 25·31 | + 0·12 | 110·34 | — 0·14 |
| Zn, | 25·38 | + 0·19 | 110·27 | — 0·21 |
| Cd, | 25·47 | + 0·28 | 110·56 | + 0·08 |
| Fe, | 25·27 | + 0.08 | 110·38 | — 0·10 |
| Co, | 25·52 | + 0·33 | 110·13 | — 0·35 |
| Ni, | 25·28 | + 0·09 | 110·37 | — 0·11 |
| Cu, | 25·35 | + 0·16 | 110·30 | — 0·18 |
| Mean value, omitting the insoluble fluorides and lithium, | 25·19 | — | 110·48 | — |

An inspection of this table shows us at once the irregularity in the case of the insoluble fluorides. Magnesium fluoride is 2·62 calories too low in one case and 2·68 in the other, or a mean of 2·65. It is therefore probable that when this fluoride precipitates from a solution it absorbs about 2·65 calories, and that if it could be retained in a very dilute solution, its heat of formation would be 2·65 calories greater. Similarly, the heat of formation of calcium fluoride in aqueous solution might be about 3·75 calories, and of strontium fluoride 3·25 calories less that when the fluorides are precipitated. But what are we to say of lithium, that pattern of good behavior in all its other thermal relations? Here is certainly an anomaly, whose explanation, I think, lies in the fact that lithium fluoride is the most nearly insoluble salt of lithium, and Petersen has either omitted to say that there was a precipitate in this case, or he has given us a wrong value for the reaction. We have very strong grounds for concluding that the true heat of forma-

tion of lithium fluoride in aqueous solution is about four calories less than the value which is deduced from Petersen's experiments on neutralization. The variations in the case of the other fluorides in the above table are so small that we may conclude that we know their true heat of formation within the limits of experimental error.

## THE DIAZOTYPE PROCESS OF PHOTOGRAPHIC DYEING AND PRINTING.

BY JOHN CARBUTT.

[*Communicated to the Chemical Section, April 21, 1891.*]

The subject I have the pleasure to bring before the Section this evening is the "Diazotype Process of Photographic Dyeing and Printing," the discovery of Mr. Arthur G. Green, of London. It is a new method of producing designs in fast colors on cotton, linen, silk, paper, etc., either from hand-drawn designs on a transparent or semi-transparent medium, or by use of a photographic transparency.

It was first made public at a meeting of the British Association for the Advancement of Science, held at Leeds last September.

It is distinctly a positive process; that is, it yields a positive from a positive. The operations are five in number, viz: dyeing, sensitizing, printing, developing and washing, corresponding very closely in number of operations required in preparing and printing on paper by the direct silver process of photographic printing. Primuline is the base of the new "diazotype," and is already in extensive use for dyeing calico in various tints.

*Dyeing.*—The first operation, then, is to dye our material with "primuline." To do this take 100 grains of "primuline," add to it twenty ounces of distilled water brought to a boil in a flask over a Bunsen burner; when dissolved, pour into a porcelain dish, and immerse the fabric, cotton cloth (the cotton must be free from dressing), or silk, and as soon as the pieces seem thoroughly impregnated with the dye,

remove and rinse in plain water, and squeeze as dry as possible, or place between sheets of blotting paper. The fabric so prepared has a primrose hue, and so far is insensitive to light.

*Sensitizing.*—The second operation, or sensitizing, is accomplished by immersing the dyed fabric in a solution formed of sodium nitrate sixty grains, cold water thirty-two ounces, oxalic acid 100 grains, previously dissolved in two ounces of water. Each piece is immersed separately and soaked for two or three minutes, it is then rinsed in water and dried. The color of the fabric should be of a reddish-yellow hue, and is sensitive to light; the operation should be performed in a weak light, and the pieces dried in the dark.

*Printing.*—Place in a printing frame a glass transparency, and place over it a diazotized fabric in contact, and expose to daylight ten to twenty minutes, or sunlight four to seven minutes. The greater the contrast in the transparency, the greater will be the contrast in the finished print, the action of daylight being to decompose the azo derivative, and so prevent reaction with the "developers," so-called, to be afterwards applied; but if we take a piece of the sensitive material that has not been exposed to light, and apply one or more of the developers, or, as a dyer would call it, a "mordant," we at once develop the full tint or color by the action of that particular solution used. This I will now illustrate.

*Developing.*—I have here a piece of porcelain coated with a solution of gelatine and primuline, and sensitized in the same bath as the cotton cloth. I now paint over one-fifth of its surface, consecutively, with each of the following five solutions or developers:

No. 1, as you see, develops a red color.

No. 2 produces a yellow.

No. 3 produces an orange.

No. 4 produces a purple.

No. 5 produces a dark brown or black.

It only remains to well rinse this in water, when the colors will be found fixed and permanent. This demonstra-

tion will illustrate the possibility of producing the several colors on one and the same picture, as follows: Mix a portion of each developer with a thin starch paste, and, with a camel's-hair pencil, paint over the parts wanted of a particular color, with the particular solution intended to supply that color, of course in a weak light, as the image is faintly visible after exposure under the transparency.

The composition of the five developers just used is as follows—and it is only right to say here that I am indebted for the formulæ of these solutions to two photographic journals, *The British Journal of Photography* and *Anthony's Photographic Bulletin:*

DEVELOPERS.

*No. 1—Red.*

| | |
|---|---|
| Betanaphthol, | 30 grains. |
| Caustic soda, | 40 grains. |
| Water, | 10 ounces. |

*No. 2—Yellow.*

| | |
|---|---|
| Crystallized carbolic acid, | 50 grains. |
| Water, | 10 ounces. |

*No. 3—Orange.*

| | |
|---|---|
| Resorcin, | 30 grains. |
| Water, | 10 ounces. |
| Caustic soda, | 45 grains. |

*No. 4—Purple*

| | |
|---|---|
| Naphthylamin, | 60 grains. |
| Water, | 10 ounces. |
| Oxalic acid, | 6 grains. |

*No. 5—Black.*

| | |
|---|---|
| Eikonogen, | 50 grains. |
| Water, | 10 ounces. |

Transparencies on glass, and positives on celluloid and opal, can be produced as shown by the specimens I have here, and which can be inspected at the close of the meeting.

The composition of the coating is as follows:

| | |
|---|---|
| Water (distilled) | 20 ounces. |
| Gelatine, | 1 ounce. |
| Primuline, | 80 grains. |
| Chrome alum, | 2 grains. |

Put the gelatine to soak in six ounces of water, dissolve the primuline in twelve ounces of hot distilled water, and when dissolved add the gelatine and the chrome alum—dissolved in the remaining two ounces of water—filter through cotton, and flow while warm on the glass or porcelain. When dry immerse for two minutes in the sensitizing solution, wash for five minutes and allow to dry in the dark. The operation of printing and developing is the same as for prints, or cotton, etc.

# PROCEEDINGS

OF THE

# ELECTRICAL SECTION,

OF THE

## FRANKLIN INSTITUTE.

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[*Proceedings of the stated meeting of the Electrical Section, held Tuesday, May 5, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 5, 1891.

Prof. EDWIN J. HOUSTON, President, in the chair.

Present, forty-eight members and visitors.

The minutes of the previous meeting were read and approved.

The treasurer presented bills for printing and clerical work, which were ordered paid when approved.

The committee on admissions reported four regular and ten associate members elected since last meeting.

The committee appointed to consider the subject of re-wiring the Institute building, presented a report suggesting certain changes in the present wiring, and stating the cost at which they could be made. The report was accepted and referred to the board of managers.

Three nominations to membership were referred to the committee on admissions.

Mr. David Brooks presented a communication on "The Value of Oil as an Insulator for High Voltage Currents," illustrated with some brilliant experiments. It was referred for publication.

Prof. Henry Crew gave a description of "Ewing's Theory of Induced Magnetism," illustrated with a model made after his suggestions, and with charts of typical magnetic phenomena that may be explained on this hypothesis. The communication was discussed by Prof. Houston and Mr. Pike, and referred for publication.

Mr. John Hoskin read a paper on "A Rough-and-Ready Dynamometer." Referred for publication.

There was considerable discussion on the contents of the Question-Box.

The meeting then adjourned. L. F. RONDINELLA, *Secretary.*

# A ROUGH-AND-READY DYNAMOMETER FOR SMALL MOTORS.

By John Hoskin.

[*Read at the meeting of the Electrical Section, held May 5, 1891.*]

I have been requested to bring to your notice this evening a friction-brake dynamometer that is by no means new, but is one that is deserving of being more widely known by electricians than appears to be the case.

Like the well-known Prony brake it acts as an absorption dynamometer; and without detracting from the acknowledged value of this instrument, especially for testing the value of large prime-movers, yet we need something more portable, more convenient to use, in the very numerous cases where it is desirable to test the efficiency of small motors.

We need a rough-and-ready instrument that is portable, inexpensive, readily used, and at the same time reliable.

This we find in a friction-brake dynamometer, one of the many modifications of those illustrated by Mr. William Worby Beaumont, in his paper on friction-brake dynamometers, read before the Institution of Civil Engineers in London, November 13, 1888, and published in 1889 in the *Proceedings* of the Institution.

Its construction requires only the use of a leather belt with a spring balance attached to one end, and a suitable weight at the other. The belt is to be thrown over the belt pulley of the motor, the spring balance is fastened to the floor base, or support of the motor to be tested, and the weighted end hangs pendant on the side of the pulley which, when in motion, will tend to lift the weight. When the motor is at rest, the strain of the weight should be read off on the spring balance. This reading we will call $W$. When the current is switched on and the motor runs at speed, the spring balance should again be read off, since the friction of the pulley on the belt will have a tendency to raise the weight; this reading we will call $W'$. The difference

between $W'$ and $W''$ in pounds, multiplied by the circumference of the pulley in feet (including one-half the belt thickness on each side), and this by the number of pulley revolutions per minute will give the foot-pounds of mechanical energy, which can be compared with the electrical energy required to produce it, in the usual manner.

Thus, in a few minutes with the aid of a speed counter or tachometer, a voltmeter and an ammeter, the efficiency of a motor can be determined, and its ability to do a desired amount of work ascertained at once, instead of being left to guess-work, as would often be the case if more bulky or elaborate apparatus were needed.

It should not be imagined from these remarks that this form of dynamometer is applicable to small motors only; but it is evident that for testing larger machines where many horse-power have to be measured, the apparatus needs more elaboration, especially in the use of friction blocks under the belt or pulley strap, their lubrication, and the use of a dash-pot to steady the brake when the motive-power is irregular.

But I need not enlarge on this, except to say that in these particulars, whether using steel strap, or leather belt with friction blocks, or rope friction, the same care is needed as in the Prony brake to obtain correct readings.

Before concluding, I submit to your consideration the value of the Waldron rotary pump for use as a dynamometer, although I have never heard that it has been applied to that purpose. In examining one of these engines recently for other purposes it occurred to me that it would serve as an excellent dynamometer.

This pump is operated by rotary piston blades working in a chamber, without leakage, and with but small friction, the amount of which can readily be ascertained and calculated for use as a "constant." Its capacity per revolution, and the number of revolutions being known, as also the pressure against which it works, which can be regulated by a pressure gauge, the foot-pounds of work are at once arrived at.

This method of measurement will correctly register the

work done, although the speed may be irregular; and its results can be made more accurate than that of the friction dynamometer, because not subject to the irregularities arising from differences in lubricants, temperature, etc., which makes it necessary to use adjusting screws in most forms of friction-brake dynamometers.

## THE VALUE OF OIL AS AN INSULATOR FOR HIGH VOLTAGE CURRENTS.

BY DAVID BROOKS.

[*Read before the Electrical Section, May 5, 1891.*]

Even as late as 1884, in the electrical works, oils were placed among conductors. For instance, James T. Sprague, in the second edition of his book, places them among conductors "in the order of their specific gravity." His first patent for the use of oil as an insulator was taken out in 1878, and now the matter is receiving great attention among the electricians of Europe. In the *London Electrical Review* there is an account of tests by Siemens and Halske, of Berlin, in which they state that an ordinary Siemens electric light cable was inserted, and broke down at a pressure of some 15,000 volts, but when oil was used, it perfectly withstood the pressure as high as 20,000 volts.

Oil has been used in Switzerland with complete success, not only for insulating wires, but also for transformers.

The writer has made the following experiment to show how much better oil is than the air for insulation. A large Holtz machine that sparked 7·5 inches through the air was unable to puncture the insulation of a cable of twisted wires separated one-fourth of an inch, when immersed in oil.

The ends of the twisted wires, were spliced to rubber-covered wires, and these were attached to the poles of the Holtz machine, after glass tubes had been drawn over them. The twisted wires were then placed in a jar contain-

ing oil with a layer of water floating on it, the oil being heavier than the water.

The spark broke through the tubes from wire to wire above the oil; the part of the jar containing water the tubes were broken opposite the splice, while the twisted wires in the oil stood the entire pressure of the machine, 7·5 inches spark. Such a spark would be equivalent to 175,000 volts, as defined by Warren De La Rue, between a point and a disk, but this spark of 7·5 inches was between two spheres which requires a much higher voltage.

When no glass tubes were used to protect the conductors, the voltage or tension was much reduced by silent or brush discharge, blue sparks passing through the rubber covering. When bare wires were used to connect the two poles of the Holtz machine, still less tension was produced on account of leakage through the air.

The experiment tends to show that the air is not a good insulator for very high voltages, and also to confirm the experiments made in Switzerland as to the value of oil for insulating transformers, and protecting them from destruction by lightning.

Experiments have also been made with heavily insulated electric light cables for conveying high voltages. None of them stood a tension above 12,000 volts, and most of them broke down by the use of less than 10,000 volts.

# BOOK NOTICES.

*A Treatise on Electro-Metallurgy:* Embracing the application of electrolysis to the plating, depositing, smelting and refining of various metals, and to the reproduction of printing surfaces and art-work, etc. By Walter G. McMillan, F.I.C., F.C.S., etc. With numerous illustrations. London: Charles Griffin & Co. Philadelphia: J. B. Lippincott Company. 1891. (8vo, pp. xv–287; price, $3.50.)

The present volume forms a timely contribution to the literature—by no means voluminous—of electro-metallurgy. The author's aim has been judiciously to combine theory and practice, to enable the practical plater and refiner to acquire a knowledge of the fundamental principles of his art, by which to control and guide their practice, and to improve it along correct lines. To this end, the author's preliminary chapters, embracing an exposition of general principles, sources of current, and the general conditions to be observed in electro-deposition, are most excellent.

The chapters on the arrangement and disposition of the plant, preparation of work, as also those treating of the deposition of specific metals, give, without needless repetition, the most approved rules of practice and the results of the most recent work of specialists in this branch of applied electricity. The subject of industrial electro-metallurgical operations, which is at present attracting much attention, might have been treated at greater length, and would have added substantially to the value of the book, but that which is given is well-digested and conveys much information in limited space. On the whole, Mr. McMillan's book will be found to present the subjects with which it deals in very convenient form, and with commendable clearness and accuracy. W. H. W.

*A Move for Better Roads.* Essays on roadmaking and maintenance and road laws, for which prizes of honorable mention were awarded through the University of Pennsylvania, by a Committee of Citizens of Philadelphia, with a synopsis of other contributions and a review by the Secretary, Lewis M. Haupt, A.M., C.E., Professor of Civil Engineering, University of Pennsylvania, also an introduction by Wm. H. Rhawn, Chairman of the Committee. Philadelphia: University of Pennsylvania Press. 1891.

Our young country seems now to have reached that age (naturally delayed by the advent and development of railroads) when attention begins to be bestowed upon the condition of its highways. From all quarters come welcome evidences of a general awakening in this respect. The manufacturers of bicycles, so far from fearing to show their hand, come boldly forward as prominent champions of the movement. Difficult as we may find it to persuade ourselves that these gentlemen have lost sight of their personal interests in pushing this agitation, we may well afford to rejoice that the interests of a limited class are found to be here identical with those of the community at large.

In his introduction to this series of essays, Mr. Rhawn, the Chairman of the Citizens' Committee who awarded the prizes, refers to the encouragement extended to the committee by Dr. Wm. Pepper, the Provost, and Prof. Lewis M. Haupt, Professor of Civil Engineering of the University, and expresses the obligations of the committee to the authors of the several papers contributed.

The committee were moved to their action by the belief that the chief difficulty in the way of improvement is ignorance on the part of our people as to what a good road is, and it is with a view to doing something to dispel this ignorance that they solicited these papers and offered their liberal prizes, of $400, $200 and $100, respectively, with honorable mention (at the discretion of the Board of Adjudicators) for other contributions.

The first prize was awarded to Henry Irwin, B.A., C.E., Canadian Pacific Railway, Montreal; the second to David H. Bergey, B.Sc., M.D., North Wales, Penna.; the third to James Bradford Olcott, South Manchester, Conn.; and honorable mention, without reference to order, to Edwin Satterthwait, Jenkintown, Pa.; Charles Punchard, 1223 Hollywood Avenue, Philadelphia; George B. Fleece C.E., Memphis, Tenn.; Frank Cawley, B.S., Swarthmore College, Penna.; and Francis Fuller McKenzie, C.E., 5774 Germantown Ave., Philadelphia.

The papers of these gentlemen, naturally covering much the same ground, are here presented, and followed by a Digest by Prof. Haupt of the contents of the remaining contributions, abstracts from miscellaneous communications received upon the general subject, notes by the Secretary, Prof. Haupt, and a copy of the Rules of the Road Improvement Association, of London.

In his notes, the Secretary endeavors to disabuse the agricultural mind of the impression "that the cost of transforming mud roads into macadam is so great as to be impracticable" Adding $4,000,000 estimated as wasted annually "in Pennsylvania alone in consequence of her poor and often impassable roads" to an equal sum raised by road taxes and wasted in "useless attempts to build a permanent structure out of incoherent, perishable materials over improper locations," we have an annual loss, through bad roads, of $8,000,000.

He points out that road improvement is obstructed not only by "ignorance as to the benefits to result from it," but also by "distrust as to the integrity of those who may be selected or appointed to conduct the work and handle the means;" and urges the employment in this work of "the civil engineers and surveyors resident in the great Commonwealth of Pennsylvania, whose reputation for skill and honesty is worth more to them than money, and who are deeply interested as citizens in promoting this long-needed reformation."

As to the raising of means for road improvement, the Secretary favors "State aid under proper restrictions," but "no public work of this character should be undertaken until a competent civil engineer is appointed to represent the interests of the State." The abolition of the system of "working out" road taxes is strongly advocated.

After brief remarks touching the dimensions and construction of roads, the Secretary concludes his notes by discussing "Soils and their adaptation to roads," in which he urges the importance of locating roads upon suitable ground, and gives data respecting the shrinkage, absorption and saturation of various soils, their behavior under changes of temperature and their rates of drying.

The Board of Adjudicators recommended to the committee, irrespective of the relative merits of the papers selected for publication :

(1) That in the improvement of roads, the macadam system, consisting of small angular fragments, in sizes not exceeding from two to two and one-half inches in their largest dimension, according to the quality, should be used, wherever a stone surface is both practical and justifiable.

(2) That the minimum width of the metalled surface for a single track should be a demirod (eight and one-quarter feet), of such depth as the amount of traffic and character of the subsoil may require, to be determined by the engineer in charge.

(3) The bed to receive the stone must be so prepared that it cannot be saturated with water, and to accomplish this, great attention should be paid to the character and drainage of the subsoil.

(4) That there should be legislative enactment regulating the width of the tires of wheels, and that the minimum width of all cart, dray, wagon and other heavy-draught vehicles should be four inches, to be increased when the capacity of the vehicle exceeds half a net ton per wheel, at the rate of one inch for each 400 pounds in excess. T.

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*A Text-book on Roofs and Bridges.* Part II, Graphic Statics. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and Henry S. Jacoby, Instructor in Civil Engineering in Lehigh University, New York : John Wiley & Sons. 1890.

This volume represents the second of the four parts into which the course in roofs and bridges at Lehigh University is divided. Part I, treating of stresses in simple trusses, appeared in 1888, and it is much to be hoped that in due time the entire course will be completed by the publication of the two remaining portions, viz : Part III, the design of a bridge, with details and the preparation of working drawings ; and Part IV, the discussion of cantilever, suspension and arched bridges.

The works forming this series make no pretensions to novelty, except in their arrangement and in the manner of presentation of the subject ; but the authors, in their preface to Part II, invite attention to the abbreviated process employed in some of the diagrams for wind stresses, to the method of determining stresses due to initial tension, and to portions of the analysis of maximum moments and shears under locomotive wheels, as being in some respects novel as well as of practical value.

The present volume, the result of the combined labors of Professor Merriman and Instructor Jacoby, bears evidence of the same ability and conscientiousness which have marked the productions of the author first named. The

typography is excellent, and it seems unfortunate that so exemplary a work should be marred by faulty illustrations Many of the cuts are rendered annoyingly indistinct by being unnecessarily crowded, and blurred by carelessness in their preparation or printing, or both.

In a text-book like this, intended to be studied as a whole from end to end, the absence of an index may perhaps be more readily condoned than in a book of reference, to be consulted occasionally for information on special subjects. T.

## Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, May 20, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 20, 1891.

JOS. M. WILSON, President, in the chair.

Present, 220 members and twenty-six visitors.

Additions to membership since last report, eleven.

Mr. S. Lloyd Wiegand, from the Committee on Science and the Arts, presented an abstract of the investigation and conclusions of the committee in the case of the method of manufacturing truck-wheel centres invented by Mr. Samuel M. Vauclain, and carried on extensively at the Baldwin Locomotive Works.

Prof. Coleman Sellers, by invitation, gave an excellent description, with illustrations, of the plans of the Cataract Construction Company, for the utilization, to the extent of 120,000 horse-power, of the water-power of Niagara Falls. The speaker's remarks embraced also some account of observations upon subjects of engineering interest, made by him during a recent visit to Europe as one of the Board of Consulting Engineers, commissioned by the Company to examine and report upon the most recent methods and examples of power transmission, and as representing the United States on the International Niagara Commission and kindred subjects. (Referred for publication.)

The thanks of the meeting were voted to the speaker, with the request that he continue his remarks at the next stated meeting.

In acknowledging the action of the meeting, Prof. Sellers stated that though he might be unable to do so at the June meeting, he would take pleasure in addressing the Institute at some later date.

Mr. W. N. Jennings exhibited a second instalment of lantern views illustrative of characteristic local subjects. These were well received.

The Secretary presented a brief report. Adjourned.

WM. H. WAHL, *Secretary.*

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW
FOR NOVEMBER, 1890.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 30, 1890.

### TEMPERATURE.

The mean temperature of 59 stations for November, 1890, was 41°·5, which is over 2°·0 above the normal, and 0°·4 below the corresponding month of 1889.

The mean of the daily maxima and minima temperatures 50°·4 and 33°·1 give an average daily range of 17°·3, and a monthly mean of 41°·7.

Highest monthly mean, 47°·8 at Uniontown.

Lowest monthly mean, 34°·0 at Wilkes-Barre.

Highest temperature recorded during the month, 78°·0 on the 7th at Uniontown.

Lowest temperature, 10°·0 on the 29th at Wilkes-Barre.

Greatest local monthly range, 58° at Charlesville.

Least local monthly range, 42° at Catawissa, Harrisburg, Selins Grove and Eagles Mere.

Greatest daily range, 47° at Charlesville on the 8th.

Least daily range, 1° at Rimersburg on the 26th, Clarion the 4th and Petersburg the 27th.

From January 1, 1890, to November 30, 1890, the excess in temperature at Philadelphia was 755°, at Erie 144° and at Pittsburgh 784°.

The coldest period of the month was on the 28th and 29th.

### BAROMETER.

The mean pressure for the month, 30·08, is about ·03 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·41 at Harrisburg on the 16th, and the lowest 29·53 at Erie on the 17th.

### PRECIPITATION.

The average rainfall 1·49 inches for the month, is a deficiency of 2·00 inches.

The largest monthly totals in inches were Columbus, 4·29; Erie, 3·32; and Somerset, 3·00.

The least were Blue Knob, 0·78; Philadelphia, 0·80; York, 0·80; Bethlehem, 0·82; Wellsboro, 0·93; Forks of Neshaminy, 0·95; and Westtown, 0·97.

The heaviest rainfall occurred on the 17th. The snow fall was light, and at most stations too small for measurement. The largest totals were Blue Knob, 5·5 inches; Grampian Hills, 3·5 inches; and Columbus, 3·0 inches.

### WIND AND WEATHER.

The prevailing wind was from the West. The weather was above the normal in temperature, and below in the amount of precipitation, and number of rainy days.

Average number: Rainy days, 8; clear days, 9; fair days, 10; cloudy days, 11.

### MISCELLANEOUS PHENOMENA.

*Hail.*—Blue Knob, 2d; Emporium, 12th; Wilkes-Barre, 19th; Columbus, 19th, 20th; Dyberry, 12th.

*Snow.*—Charlesville, 20th, 27th; Altoona, 4th, 28th; Blue Knob, 8th, 19th, 20th, 26th, 27th; Hollidaysburg, 4th, 20th, 26th, 27th; Tipton, 4th; Wysox, 3d, 4th, 10th, 20th, 23d, 27th; Le Roy, 1st, 20th, 23d; Quakertown, 4th, 27th; Johnstown, 3d, 4th, 19th, 20th, 27th, 30th; Emporium, 1st, 3d, 4th, 19th, 20th; Mauch Chunk, 4th; State College, 3d, 4th, 20th; Phillipsburg, 4th, 9th, 20th; Coatesville, 4th, 20th, 27th, 29th, 30th; Westtown, 19th, 27th; Rimersburg, 3d, 4th, 20th, 27th; Clarion, 4th, 26th, 27th; Grampian Hills, 4th, 19th, 20th, 27th; Lock Haven, 4th; Catawissa, 20th; Meadville, 4th, 19th, 20th; Carlisle, 20th; Swarthmore, 20th; Uniontown, 3d, 4th, 27th; Huntingdon, 4th, 20th; Petersburg, 4th, 20th, 27th; Lancaster, 4th, 20th, 27th; New Castle, 4th, 27th; Myerstown, 3d, 20th; Wilkes-Barre, 3d, 4th, 12th, 20th; Nisbet, 20th; Pottstown, 20th; Philadelphia, 4th, 20th; Girardville, 3d, 4th, 20th; Selins Grove, 4th, 19th, 20th; Somerset, 4th, 19th, 27th; Eagles Mere, 4th, 12th, 19th, 20th, 23d, 27th; Wellsboro, 3d, 20th, 22d, 23d; Lewisburg, 3d, 20th; Columbus, 1st, 3d, 19th, 20th, 27th, 30th; Canonsburg, 3d, 4th, 27th; Dyberry, 4th, 19th, 23d; Honesdale, 4th, 12th, 21st, 23d; Ligonier, 4th, 27th; York, 20th; Indiana, 26th, 27th; Greenville, 2d, 4th, 20th, 27th, 30th.

*Frost.*—Pittsburgh, 1st, 5th, 21st; Charlesville, 5th, 14th, 21st, 24th, 28th, 29th; Altoona, 4th, 5th, 6th, 12th, 13th, 14th, 19th, 20th, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th; Blue Knob, 1st, 3d, 4th, 11th, 14th, 19th, 20th, 21st, 22d, 23d, 24th, 27th, 28th, 29th, 30th; Hollidaysburg, 5th, 14th, 21st, 24th, 30th; Tipton, 1st, 4th, 5th, 6th, 7th, 13th, 14th, 15th, 19th, 20th, 21st, 24th, 26th, 27th, 28th, 29th, 30th; Wysox, 2d, 3d, 4th, 5th, 6th; Le Roy, 1st, 3d, 4th, 5th, 13th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th; Forks of Neshaminy, 1st, 4th, 5th, 6th, 14th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th; Quakertown, 1st, 4th, 5th, 6th, 7th, 13th, 21st, 23d, 24th, 26th, 27th, 28th, 29th, 30th; Emporium, 5th, 6th, 14th, 15th, 21st, 24th, 27th, 28th, 30th; State College, 3d, 5th, 6th, 7th, 14th, 21st, 24th, 29th, 30th; Phillipsburg, 15th, 21st, 23d, 24th; Coatesville, 1st, 2d, 5th, 6th, 7th, 12th, 13th, 14th, 15th, 19th, 23d, 24th, 25th; Phœnixville, 1st, 5th, 14th, 21st, 24th, 29th, 30th; Westtown, 1st, 5th, 14th, 23d, 24th, 29th; Rimersburg, 13th, 24th; Grampian Hills, 5th, 14th, 28th; Lock Haven, 24th, 25th, 26th, 27th, 28th,

# Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service

| County. | Station. | Elevation above Sea Level (feet). | Barometer Reduced to Sea Level. | | | Temperature. | | | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maximum. | | Minimum. | | | Daily Range. | | | | | | | | |
| | | | Mean. | Highest. | Lowest. | Mean. | Highest. | Date. | Lowest. | Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. |
| Allegheny,[1] | Pittsburgh, | 847 | 30·100 | 30·390 | 29·570 | 45·4 | 73·0 | 17 | 23·0 | 28 | 52·3 | 38·6 | 13·7 | 28·0 | 21 | 4·0 | 26 | 70·4 | 35·2 | 1·14 | . . . |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 42·5 | 73·0 | 17 | 15·0 | 28 | 55·1 | 30·6 | 24·5 | 47·0 | 8 | 5·0 | 12 | 77·0 | 36·0 | 1·57 | . . . |
| Blair,[2] | Altoona, | 1,181 | . . . | . . . | . . . | 47·2 | 69·0 | 18 | 22·0 | 28 | 54·9 | 39·4 | 15·5 | 32·0 | 28 | 6·0 | 2 | 67·1 | 36·3 | 1·07 | . . . |
| Blair, | Blue Knob, | 2,500 | . . . | . . . | . . . | 37·5 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0·78 | 5·50 |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 42·7 | 71·0 | 6, 17 | 20·0 | 28, 29 | 54·0 | 32·0 | 22·0 | 45·0 | 6 | 8·0 | 27 | 81·0 | 38·0 | 1·48 | 0·50 |
| Blair, | Tipton, | 915 | . . . | . . . | . . . | 42·8 | 76·0 | 8 | 21·0 | 28 | 52·3 | 35·2 | 17·1 | 44·0 | 7 | 3·0 | 18 | . . . | . . . | 1·57 | 1·00 |
| Bradford, | Wysox, | 718 | 30·075 | 30·387 | 29·513 | 39·0 | 66·0 | 7 | 17·0 | 29 | 46·6 | 30·1 | 16·5 | 34·5 | 7 | 5·0 | 27 | 80·8 | 33·2 | 0·81 | . . . |
| Bradford, | Le Roy, | 1,400 | . . . | . . . | . . . | 38·0 | 65·0 | 7 | 16·0 | 28 | 44·1 | 32·7 | 11·4 | 21·0 | 6 | 3·0 | 12 | . . . | . . . | 0·89 | 0·30 |
| Bucks, | Forks of Neshaminy (28 days), | . . . | . . . | . . . | . . . | 42·1 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0·95 | . . . |
| Bucks, | Quakertown, | 536 | 30·080 | 30·450 | 29·590 | 40·1 | 63·0 | 18 | 18·0 | 29 | 51·9 | 30·1 | 21·8 | 34·5 | 6 | 9·0 | 11 | 77·4 | 33·0 | 1·24 | . . . |
| Cambria,[1] | Johnstown, | 1,184 | 30·129 | 30·438 | 29·600 | 43·7 | 72·0 | 9, 17 | 21·0 | 28 | 52·4 | 35·0 | 17·4 | 37·0 | 6 | 6·0 | 27 | 84·7 | 36·2 | 2·34 | 1·00 |
| Cameron, | Emporium, | 1,030 | . . . | . . . | . . . | 41·5 | 67·0 | 7, 17 | 18·0 | 28 | 51·6 | 32·0 | 19·6 | 34·0 | 5 | 8·0 | 2 | . . . | . . . | 2·16 | 1·50 |
| Carbon,[1] | Mauch Chunk (29 days), | 550 | . . . | . . . | . . . | 39·0 | . . . | . . . | 17·0 | 29 | 47·3 | 30·7 | 16·6 | 29·0 | 30 | 10·0 | 27 | . . . | . . . | 1·00 | 0·20 |
| Centre, | State College—Agricultural Experiment Station, | 1,191 | 30·030 | 30·377 | 29·443 | 41·2 | 66·0 | 7 | 17·0 | 28 | 49·3 | 34·1 | 15·2 | 31·0 | 6 | 4·0 | 19 | 74·0 | 33·2 | 1·46 | 0·60 |
| Chester, | Phillipsburg (24 days), | 1,350 | . . . | . . . | . . . | 40·1 | 70·0 | 9 | 19·0 | 21 | 49·5 | 32·7 | 16·8 | 32·0 | 9 | 10·0 | 3 | . . . | . . . | 1·27 | 0·50 |
| Chester, | West Chester, | 455 | 30·053 | 30·344 | 29·524 | 43·6 | 71·0 | 8 | 20·0 | 28 | 52·5 | 35·8 | 16·7 | 27·0 | 14 | 5·0 | 12 | 69·0 | 34·0 | 1·23 | . . . |
| Chester,[1] | Coatesville, | 380 | . . . | . . . | . . . | 41·4 | 73·0 | 8 | 17·0 | 29 | 55·5 | 31·1 | 24·4 | 40·0 | 6 | 9·0 | 12 | . . . | . . . | 1·07 | . . . |
| Chester, | Kennett Square, | 275 | . . . | . . . | . . . | 39·8 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0·83 | . . . |
| Chester, | Phœnixville, | . . . | 30·086 | 30·371 | 29·615 | 44·9 | 73·0 | 8 | 22·0 | 28 | 52·9 | 35·9 | 18·0 | 29·0 | 7 | 6·0 | 12 | 80·8 | 35·5 | 1·22 | . . . |
| Chester, | Westtown, | 350 | 30·124 | 30·409 | 29·647 | 43·2 | 70·0 | 8 | 22·0 | 29 | 51·5 | 35·7 | 15·8 | 28·0 | 14 | 3·5 | 12 | . . . | . . . | 0·97 | . . . |
| Clarion, | Rimersburg, | 1,500 | . . . | . . . | . . . | 40·2 | 62·0 | 6, 7 | 18·0 | 28 | 44·8 | 34·7 | 10·1 | 28·0 | 21 | 1·0 | 26 | . . . | . . . | . . . | . . . |
| Clarion, | Clarion—State Normal School (27 days), | 1,530 | . . . | . . . | . . . | 41·7 | 63·0 | 6 | 17·0 | 28 | 46·8 | 28·7 | 18·1 | 33·0 | 21 | 1·0 | 4 | 82·0 | 36·0 | 1·77 | . . . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 39·2 | 68·0 | 7, 9, 17 | 16·0 | 28 | 46·2 | 32·9 | 13·3 | 34·0 | 21 | 2·0 | 3 | . . . | . . . | 1·96 | 3·50 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | 41·9 | 66·0 | 16 | 15·0 | 28 | 50·1 | 32·6 | 17·5 | 36·0 | 21 | 4·0 | 19 | . . . | . . . | 1·35 | 0·50 |
| Columbia, | Catawissa, | 491 | . . . | . . . | . . . | 43·0 | 64·0 | 7 | 22·0 | 28 | 48·5 | 34·6 | 13·9 | 29·0 | 7 | 4·0 | 26 | . . . | . . . | 1·17 | 0·50 |
| Crawford, | Meadville, | 1,300 | 30·058 | 30·450 | 29·600 | 40·2 | 65·0 | 17 | 15·0 | 28 | 45·9 | 34·5 | 11·4 | . . . | . . . | . . . | . . . | 83·0 | 33·5 | 2·81 | 1·00 |
| Cumberland, | Carlisle, | 480 | . . . | . . . | . . . | 42·5 | 66·0 | 8 | 19·0 | 29 | 53·5 | 33·1 | 20·4 | 37·0 | 6 | 8·0 | 12 | 84·9 | 37·4 | 0·81 | . . . |
| Dauphin,[1] | Harrisburg, | 361 | 30·108 | 30·412 | 29·633 | 42·8 | 64·0 | 8 | 22·0 | 28 | 50·5 | 36·4 | 14·1 | 26·0 | 14 | 4·0 | 12 | 72·2 | 33·8 | 1·12 | . . . |
| Delaware, | Swarthmore—Swarthmore College, | 190 | 30·066 | 30·343 | 29·680 | 43·4 | 71·0 | 8 | 22·0 | 28 | 52·4 | 37·1 | 15·3 | 25·0 | 16 | 4·0 | 12 | 77·9 | 36·7 | 0·88 | 0·10 |
| Erie,[1] | Erie, | 681 | 30·030 | 30·390 | 29·530 | 42·0 | 66·0 | 17 | 26·0 | 27 | 48·0 | 36·0 | 12·0 | 27·0 | 21 | 4·0 | 10 | 74·0 | 33·0 | 3·32 | . . |
| Fayette, | Uniontown, | 1,000 | 30·063 | 30·312 | 29·723 | 47·8 | 78·0 | 7 | 20·0 | 28 | 55·3 | 39·8 | 15·5 | 35·0 | 7 | 3·0 | 27 | . . . | . . . | 2·25 | . . . |
| Franklin,[1] | Chambersburg—Wilson Female College, | 618 | 30·114 | 30·352 | 29·739 | 42·4 | 69·0 | 6 | 17·0 | 29 | 54·3 | 30·5 | 23·8 | 43·0 | 6 | 8·0 | 12 | 81·2 | 33·4 | 1·21 | . . . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 42·9 | 68·0 | 6 | 18·0 | 30 | 53·9 | 33·1 | 20·8 | 39·0 | 6 | 8·0 | 11 | 76·8 | 35·8 | 1·59 | . . . |
| Huntingdon,[1] | Huntingdon—The Normal College, | 650 | . . . | . . . | . . . | 43·2 | 73·0 | 7 | 20·0 | 29 | 53·5 | 32·9 | 20·6 | 45·0 | 6 | 5·0 | 1 | . . . | . . . | 1·38 | . . . |
| Huntingdon, | Petersburg, | 700 | . . . | . . . | . . . | 42·9 | 74·0 | 6 | 20·0 | 28 | 52·8 | 32·5 | 15·3 | 42·0 | 6 | 1·0 | 27 | . . . | . . . | 1·38 | . . . |
| Indiana, | Indiana—State Normal School (26 days), | 1,350 | 30·107 | 30·394 | 29·776 | 40·4 | 70·0 | 10 | 15·0 | 28 | 50·1 | 32·8 | 17·3 | 33·0 | 24 | 2·0 | 14 | 79·5 | 35·5 | 2·14 | 1·00 |
| Lancaster, | Lancaster, | 411 | 30·099 | 30·331 | 29·611 | 43·1 | 68·0 | 8, 9 | 25·0 | 27 | 53·6 | 34·5 | 19·1 | 35·5 | 19 | 8·5 | 12 | 78·2 | 39·7 | 1·04 | . . . |
| Lawrence, | New Castle, | 932 | . . . | . . . | . . . | 43·7 | 68·0 | 17 | 14·0 | 28 | 51·0 | 31·8 | 19·2 | 37·0 | 21 | 5·0 | 27 | 91·7 | 38·7 | 2·44 | 0·25 |
| Lebanon, | Myerstown, | 474 | 30·056 | 30·319 | 29·671 | 40·5 | 67·0 | 8 | 19·0 | 29 | 51·6 | 31·3 | 20·3 | 35·0 | 5 | 10·0 | 11 | 83·1 | 36·4 | 1·23 | . . . |
| Lehigh, | Coopersburg, | 520 | . . . | . . . | . . . | 41·7 | 69·0 | 8 | 21·0 | 28 | 53·2 | 34·2 | 19·0 | 30·0 | 25 | 8·0 | 12 | . . . | . . . | 0·95 | . . . |
| Lehigh,[1] | Lynnport, | 350 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Luzerne, | Drifton—Drifton Hospital, | 1,655 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . . | . . . | . . . | 34·0 | 60·0 | 25 | 10·0 | 29 | 43·4 | 24·6 | 18·8 | 37·0 | 26 | 6·0 | 15 | . . . | . . . | 1·29 | 1·34 |
| Lycoming,[1] | Nisbet, | 550 | . . . | . . . | . . . | 40·3 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 1·30 | . . . |
| Mercer,[1] | Greenville—Thiel College, | 1,000 | 30·016 | 30·377 | 29·532 | 41·4 | 66·0 | 17 | 14·0 | 28 | 49·8 | 33·1 | 16·7 | 34·5 | 21 | 5·4 | 11 | 88·8 | 34·9 | 2·32 | 2·00 |
| Mifflin, | Pottstown, | 150 | . . . | . . . | . . . | 44·0 | 71·0 | 8 | 21·0 | 29 | 53·0 | 35·0 | 18·0 | 32·0 | 8 | 4·0 | 12 | 77·0 | 36·0 | 1·00 | . . . |
| Northampton, | Bethlehem, | 360 | . . | . . . | . . . | 43·4 | 68·0 | 8 | 21·0 | 28 | 50·6 | 32·8 | 17·8 | 34·0 | 6 | 6·0 | 12 | 73·0 | 35·0 | 0·82 | . . . |
| Philadelphia,[1] | Philadelphia—Signal Office, | 117 | 30·102 | 30·410 | 29·657 | 46·4 | 70·0 | 8 | 23·0 | 28 | 54·2 | 38·9 | 15·3 | 27·0 | 7 | 7·0 | 3 | 70·2 | 34·4 | 0·80 | . . . |
| Schuylkill, | Girardville, | 1,000 | 30·048 | 30·424 | 29·685 | 40·7 | 62·0 | 6, 8 | 19·0 | 28 | 48·9 | 32·8 | 16·1 | 29·0 | 6 | 6·0 | 11 | . . . | . . . | 1·67 | 1·00 |
| Snyder, | Selins Grove, | 445 | . . . | . . . | . . . | 40·5 | 60·0 | 7, 25 | 18·0 | 28 | 47·2 | 33·8 | 13·4 | 27·0 | 7 | 3·0 | 12 | 84·6 | 36·5 | 1·54 | . . . |
| Somerset, | Somerset, | 2,250 | . . . | . . . | . . . | 41·1 | 70·0 | 17 | 32·0 | 27, 28 | 55·2 | 31·7 | 23·5 | 35·0 | 7 | 10·0 | 12 | 85·1 | 37·2 | 3·02 | 1·25 |
| Sullivan, | Eagles Mere, | 2,060 | 30·136 | 30·431 | 29·825 | 34·8 | 54·0 | 7 | 12·0 | 28 | 40·4 | 28·8 | 11·6 | 21·0 | 25 | 4·0 | 10 | 74·5 | 27·1 | 1·64 | 2·00 |
| Tioga, | Wellsboro, | 1,327 | 30·039 | 30·349 | 29·458 | 36·2 | 65·0 | 7 | 16·0 | 28 | 44·8 | 30·0 | 14·8 | 31·0 | 7 | 2·0 | 16 | 78·2 | 48·6 | 0·93 | 1·50 |
| Union,[1] | Lewisburg, | 450 | . . . | . . . | . . . | 42·0 | 64·0 | 7 | 19·0 | 28 | 51·5 | 32·6 | 18·9 | 32·0 | 7 | 6·0 | 12 | . . . | . . . | 1·21 | . . . |
| Warren, | Columbus, | 1,410 | . . . | . . . | . . . | 39·3 | 68·0 | 6 | 14·0 | 28 | 46·7 | 32·0 | 14·7 | 34·0 | 21 | 2·0 | 26 | 67·4 | 27·8 | 4·29 | 3·00 |
| Washington, | Canonsburg, | 950 | 30·097 | 30·311 | 29·619 | 42·7 | . . . | . . . | 15·0 | 28 | 52·5 | 32·9 | 19·6 | . . . | . . . | . . . | . . . | 70·4 | 32·6 | 1·91 | . . . |
| Wayne, | Dyberry, | 1,100 | . . . | . . . | . . . | 35·6 | 65·0 | 6 | 11·0 | 29 | 45·6 | 27·4 | 18·2 | 38·0 | 6 | 4·0 | 11 | . . . | . . . | 1·68 | 1·50 |
| Wayne, | Honesdale, | 1,000 | . . . | . . . | . . . | 37·2 | 59·0 | 7 | 15·0 | 27, 29 | 44·8 | 29·6 | 15·2 | 30·0 | 7 | 5·0 | 13 | 66·4 | 31·9 | 1·18 | . . . |
| Westmoreland, | Ligonier, | 1,750 | . . . | . . . | . . . | 43·7 | . . . | . . . | 15·0 | 28 | 55·3 | 32·0 | 23·3 | . . . | . . . | . . . | . . . | 74·0 | 36·0 | 2·13 | . . . |
| Wyoming,[1] | South Eaton | 660 | . . . | . . . | . . . | 40·2 | 61·0 | 18 | 17·0 | 29 | 48·5 | 32·3 | 16·2 | 30·0 | 6 | 5·0 | 12 | . . . | . . . | 0·78 | . . . |
| York,[1] | York, | 385 | 30·050 | 30·330 | 29·745 | 43·2 | 68·0 | 8 | 19·0 | 29 | 53·5 | 32·9 | 20·6 | 35·0 | 6 | 7·5 | 1 | 82·2 | 36·0 | 0·80 | . . . |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

# Voluntary Observers of the Pennsylvania State Weather Service for Nov

| Temperature. | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum. | | Mean of Maximum. | Mean of Minimum. | Daily Range. | | | | | | | | | | |
| Lowest. | Date. | | | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Number of Days Rainfall. | |
| 23°0 | 28 | 52°3 | 38°6 | 13°7 | 28°0 | 21 | 4°0 | 26 | 70°4 | 35°2 | 1'14 | . . . | 13 | |
| 15°0 | 28 | 55°1 | 30°6 | 24°5 | 47°0 | 8 | 5°0 | 12 | 77°0 | 36°0 | 1'57 | . . . | 5 | |
| 22°0 | 28 | 54°9 | 39°4 | 15°5 | 32°0 | 28 | 6°0 | 2 | 67°1 | 36°3 | 1'07 | . . . | 5 | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0'78 | 5'50 | 10 | |
| 20°0 | 28, 29 | 54°0 | 32°0 | 22°0 | 45°0 | 6 | 8°0 | 27 | 81°0 | 38°0 | 1'48 | 0'50 | 8 | 1 |
| 21°0 | 28 | 52°3 | 35°2 | 17°1 | 44°0 | 7 | 3°0 | 18 | . . . | . . . | 1'57 | 1'00 | 6 | 1 |
| 17°0 | 29 | 46°6 | 30°1 | 16°5 | 34°5 | 7 | 5°0 | 27 | 80°8 | 33°2 | 0'81 | . . . | 7 | |
| 16°0 | 28 | 44°1 | 32°7 | 11°4 | 21°0 | 6 | 3°0 | 12 | . . . | . . . | 0'89 | 0'80 | 13 | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0'95 | . . . | 9 | 1 |
| 18°0 | 29 | 51°9 | 30°1 | 21°8 | 34°5 | 6 | 9°0 | 11 | 77°4 | 33°0 | 1'24 | . . . | 7 | 1 |
| 21°0 | 28 | 52°4 | 35°0 | 17°4 | 37°0 | 6 | 6°0 | 27 | 84°7 | 36°2 | 2'34 | 1'00 | 15 | |
| 18°0 | 28 | 51°6 | 32°0 | 19°6 | 34°0 | 5 | 8°0 | 2 | . . . | . . . | 2'16 | 1'50 | 11 | |
| 17°0 | 29 | 47°3 | 30°7 | 16°6 | 29°0 | 30 | 10°0 | 27 | . . . | . . . | 1'00 | 0'20 | 6 | 1 |
| 17°0 | 28 | 49°3 | 34°1 | 15°2 | 31°0 | 6 | 4°0 | 19 | 74°0 | 33°2 | 1'46 | 0'60 | 8 | |
| 19°0 | 21 | 49°5 | 32°7 | 16°8 | 32°0 | 9 | 10°0 | 3 | . . . | . . . | 1'27 | 0'50 | 7 | |
| 20°0 | 28 | 52°5 | 35°8 | 16°7 | 27°0 | 14 | 5°0 | 12 | 69°0 | 34°0 | 1'23 | . . . | 8 | 1 |
| 17°0 | 29 | 55°5 | 31°1 | 24°4 | 40°0 | 6 | 9°0 | 12 | . . . | . . . | 1'07 | . . . | 8 | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0'83 | . . . | 6 | 1 |
| 22°0 | 28 | 52°9 | 35°9 | 18°0 | 29°0 | 7 | 6°0 | 12 | 80°8 | 35°5 | 1'22 | . . . | 10 | 1 |
| 22°0 | 29 | 51°5 | 35°7 | 15°8 | 28°0 | 14 | 3°5 | 12 | . . . | . . . | 0'97 | . . . | 5 | |
| 18°0 | 28 | 44°8 | 34°7 | 10°1 | 28°0 | 21 | 1°0 | 26 | . . . | . . . | . . . | . . . | 10 | |
| 17°0 | 28 | 46°8 | 28°7 | 18°1 | 33°0 | 21 | 1°0 | 4 | 82°0 | 36°0 | 1'77 | . . . | 4 | |
| 16°0 | 28 | 46°2 | 32°9 | 13°3 | 34°0 | 21 | 2°0 | 3 | . . . | . . . | 1'96 | 3'50 | 10 | |
| 15°0 | 28 | 50°1 | 32°6 | 17°5 | 36°0 | 21 | 4°0 | 19 | . . . | . . . | 1'35 | 0'50 | 10 | |
| 22°0 | 28 | 48°5 | 34°6 | 13°9 | 29°0 | 7 | 4°0 | 26 | . . . | . . . | 1'17 | 0'40 | 6 | |
| 15°0 | 28 | 45°9 | 34°5 | 11°4 | . . . | . . . | . . . | . . . | 83°0 | 33°5 | 2'81 | 1'00 | 10 | |
| 19°0 | 29 | 53°5 | 33 1 | 20°4 | 37°0 | 6 | 8°0 | 12 | 84°9 | 37°4 | 0'81 | . . . | 7 | |
| 22°0 | 28 | 50°5 | 36°4 | 14°1 | 26°0 | 14 | 4°0 | 12 | 72°2 | 33°8 | 1'12 | . . . | 8 | 1 |
| 22°0 | 28 | 52°4 | 37°1 | 15°3 | 25°0 | 16 | 4°0 | 12 | 77°9 | 36°7 | 0'88 | 0'10 | 4 | |
| 26°0 | 27 | 48°0 | 36°0 | 12°0 | 27°0 | 21 | 4°0 | 10 | 72°0 | 33°0 | 3'32 | . . | 13 | |
| 20°0 | 28 | 55°3 | 39°8 | 15°5 | 35°0 | 7 | 3°0 | 27 | . . . | . . . | 2'95 | . . . | 7 | 1 |
| 17°0 | 29 | 54°3 | 30°5 | 23°8 | 43°0 | 6 | 8°0 | 12 | 81°2 | 33°4 | 1'21 | . . . | 4 | 1 |
| 18°0 | 30 | 53°9 | 33°1 | 20°8 | 39°0 | 6 | 8°0 | 11 | 76°8 | 35°8 | 1'59 | . . . | 3 | 1 |
| 20°0 | 29 | 53°5 | 32°9 | 20°6 | 45°0 | 6 | 5°0 | 1 | . . . | . . . | 1'38 | . . . | 5 | 2 |
| 20°0 | 28 | 52°8 | 37°5 | 15°3 | 42°0 | 6 | 1°0 | 27 | . . . | . . . | 1'38 | . . . | 5 | |
| 15°0 | 28 | 50°1 | 32°8 | 17°3 | 33°0 | 24 | 2°0 | 14 | 79°5 | 35°5 | 2'14 | 1'00 | 7 | |
| 25°0 | 27 | 53°6 | 34°5 | 19°1 | 35°5 | 19 | 8°5 | 12 | 78°2 | 39°7 | 1'04 | . . . | 4 | |
| 14°0 | 28 | 51°0 | 31°8 | 19°2 | 37°0 | 21 | 5°0 | 27 | 91°7 | 38°7 | 2'44 | 0'25 | 9 | |
| 19°0 | 29 | 51°6 | 31°3 | 20°3 | 35°0 | 5 | 10°0 | 11 | 83°1 | 36°4 | 1'23 | . . . | 4 | 1 |
| 21°0 | 28 | 53°2 | 34°2 | 19°0 | 30°0 | 25 | 8°0 | 12 | . . . | . . . | 0'95 | . . . | 6 | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . |
| 10°0 | 29 | 43°4 | 24°6 | 18°8 | 37°0 | 26 | 6°0 | 15 | . . . | . . . | 1'29 | 1'54 | 10 | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 1'30 | . . . | 5 | |
| 14°0 | 28 | 49°8 | 33°1 | 16°7 | 34°5 | 21 | 5°4 | 11 | 88°8 | 34°9 | 2'92 | 2'00 | 12 | |
| 21°0 | 29 | 53°0 | 35°0 | 18°0 | 32°0 | 8 | 4°0 | 12 | 77°0 | 36°0 | 1'00 | . . . | 3 | 2 |
| 21°0 | 28 | 50°6 | 32°8 | 17°8 | 34°0 | 6 | 6°0 | 12 | 73°0 | 35°0 | 0'82 | . . . | 2 | 2 |
| 23°0 | 28 | 54°2 | 38°9 | 15°3 | 27°0 | 7 | 7°0 | 3 | 70°2 | 34°4 | 0'80 | . . . | 7 | 1 |
| 19°0 | 28 | 48°9 | 32°8 | 16°1 | 29°0 | 6 | 6°0 | 11 | . . . | . . . | 1'67 | 1'00 | 8 | 1 |
| 18°0 | 28 | 47°2 | 33°8 | 13°4 | 27°0 | 7 | 3°0 | 12 | 84°6 | 36°5 | 1'54 | . . . | 5 | |
| 32°0 | 27, 28 | 55°2 | 31°7 | 23°5 | 35°0 | 7 | 10°0 | 12 | 85°1 | 37°2 | 3'00 | 1'25 | 9 | |
| 12°0 | 28 | 40°4 | 28°8 | 11°6 | 21°0 | 25 | 4°0 | 10 | 74°5 | 27°1 | 1'64 | 2'00 | 3 | |
| 16°0 | 28 | 44°8 | 30°0 | 14°8 | 31°0 | 7 | 2°0 | 18 | 78°2 | 48°6 | 0'93 | 1'50 | 10 | |
| 19°0 | 28 | 51°5 | 32°6 | 18°9 | 32°0 | 7 | 6°0 | 12 | . . . | . . . | 1'21 | . . . | 6 | 1 |
| 14°0 | 28 | 46°7 | 32°0 | 14°7 | 34°0 | 21 | 2°0 | 26 | 67°4 | 27°8 | 4'89 | 3'00 | 16 | |
| 15°0 | 28 | 52°5 | 32°9 | 19°6 | . . . | . . . | . . . | . . . | 70°4 | 32°6 | 1'01 | . . . | 10 | |
| 11°0 | 29 | 45°6 | 27°4 | 18°2 | 38°0 | 6 | 4°0 | 11 | . . . | . . . | 1'68 | 1'50 | 9 | |
| 15°0 | 27, 29 | 44°8 | 29°6 | 15°2 | 30°0 | 7 | 3°0 | 18 | 66°4 | 31°9 | 1'18 | . . . | 11 | |
| 15°0 | 28 | 55°3 | 32°0 | 23°3 | . . . | . . . | . . . | . . . | 74°0 | 36°0 | 2'13 | . . . | 7 | 1 |
| 17°0 | 29 | 48°5 | 32°3 | 16°2 | 30°0 | 6 | 5°0 | 12 | . . . | . . . | 0'78 | . . . | 5 | |
| 19°0 | 29 | 53°5 | 32°9 | 20°6 | 35°0 | 6 | 7°5 | 1 | 82°2 | 36°0 | 0'80 | . . . | 6 | 1 |

| ATION. | Number of Days Rainfall. | NUMBER OF DAYS. Clear. | Fair. | Cloudy. | WIND. PREVAILING DIRECTION. 7 A. M. | 2 P. M. | 9 P. M. | OBSERVERS. |
|---|---|---|---|---|---|---|---|---|
| | 13 | 7 | 9 | 14 | W | W | W | Oscar D. Stewart, Sgt. Sig. Corps. |
| | 5 | 7 | 12 | 11 | W | SW | N | Miss E. A. G. Apple. |
| | 5 | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| | 10 | 7 | 14 | 9 | NW | NW | NW | A. H. Boyle. |
| | 8 | 10 | 11 | 9 | W | W | W | Prof. J. A. Stewart. |
| | 6 | 11 | 10 | 9 | NW | NW | W | Miss Cora J. Wilson. |
| | 7 | 7 | 4 | 19 | W | W | W | Charles Beecher. |
| | 13 | 7 | 7 | 16 | SW | SW | SW | Geo. W. T. Warburton. |
| | 9 | 12 | 12 | 4 | W | NW | NW | J. C. Hilsman. |
| | 7 | 10 | 12 | 8 | W | W | W | J. L. Heacock. |
| | 15 | 5 | 10 | 15 | S | S | S | E. C. Lorentz. |
| | 11 | 7 | 12 | 11 | NW | W | W | T. B. Lloyd. |
| | 6 | 12 | 11 | 7 | NW | NW | NW | John J. Boyd. |
| | 8 | 6 | 8 | 16 | W | W | W | Prof. Wm. Frear. |
| | 7 | 5 | 4 | 15 | SW | SW | SW | Geo. H. Dunkle. |
| | 8 | 10 | 9 | 5 | NW | NW | S | Jesse C. Green, D.D.S. |
| | 8 | 8 | 17 | 5 | W | W | W | W. T. Gordon. |
| | 6 | 10 | 13 | 7 | NW | NW | NW | Benj. P. Kirk. |
| | 10 | 10 | 16 | 4 | NW | NW | NW | Knowles Croskey. |
| | 5 | 7 | 12 | 11 | W | W | NW | Prof. Wm. F. Wickersham. |
| | 16 | 5 | 9 | 16 | W | W | W | Rev. W. W. Deatrick, A.M. |
| | 4 | 3 | 7 | 17 | SW | SW | SW | C. M. Thomas, B.S. |
| | 10 | 7 | 6 | 17 | W | W | W | Nathan Moore. |
| | 10 | 8 | 11 | 11 | W | W | W | Prof. John A. Robb. |
| | 6 | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| | 10 | 7 | 6 | 17 | W | S | N | J. & B. H. Metcalf. |
| | 7 | 8 | 12 | 10 | W | W | W | J. E. Pague. |
| | 8 | 11 | 9 | 10 | W | W | W | Frank Ridgway, Sgt. Sig. Corps. |
| | 4 | 1 | 13 | 16 | W | W | NW | Prof. Susan J. Cunningham. |
| | 14 | 5 | 8 | 17 | SW | SW | SW | Peter Wood, Sgt. Sig. Corps. |
| | 7 | 13 | 12 | 5 | NW | SW | SW | Wm. Hunt. |
| | 4 | 11 | 10 | 9 | . . . | . . . | . . . | Miss Mary A. Ricker. |
| | 3 | 12 | 11 | 7 | N | NW | N | Thomas F. Sloan. |
| | 5 | 20 | 3 | 7 | W | W | W | Prof. W. J. Swigart. |
| | 5 | 7 | 14 | 9 | N | NW | N | J. E. Rooney. |
| | 7 | 7 | 8 | 11 | NW | NW | NW | Prof. S. C. Schmucker. |
| | 4 | 8 | 15 | 7 | NW | NW | W | Lewis T. Lampe. |
| | 9 | 6 | 6 | 18 | NW | NW | SE | Wm. T. Butz. |
| | 4 | 13 | 6 | 11 | W | W | W | Wm. H. Kline. |
| | 6 | 11 | 11 | 8 | SE | NW | SE | M. H. Boye. |
| | . . . | . . . | . . . | . . . | . . . | . . . | . . . | John C. Wuchter. |
| | . . . | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| | 10 | 16 | 4 | 10 | SW | SW | SW | A. W. Betterly. |
| | 5 | . . . | . . . | . . . | W | . . . | E | John S. Gibson, P. M. |
| | 12 | 5 | 8 | 17 | SE | . . . | NW | Prof. S. H. Miller. |
| | 3 | 20 | 8 | 2 | W | W | W | Charles Moore, D.D.S. |
| | 2 | 20 | 3 | 7 | W | W | W | Lerch & Rice. |
| | 2 | 10 | 13 | 7 | NW | NW | NW | Luther M. Dey, Sgt. Sig. Corps. |
| | 8 | 11 | 10 | 9 | W | W | W | E. C. Wagner. |
| | 5 | 4 | 16 | 10 | SW | NW | NW | J. M. Boyer, |
| | 9 | 8 | 5 | 17 | NW | NW | NW | W. M. Schrock. |
| | 3 | 5 | 16 | 9 | SW | SW | SW | E. S. Chase. |
| | 10 | 2 | 10 | 18 | S | SW | N | H. D. Deming. |
| | 6 | 10 | 11 | 9 | SW | SW | SW | F. O. Whitman. |
| | 16 | 6 | 7 | 17 | SW | SW | SW | Wm. Loveland. |
| | 10 | 9 | 12 | 9 | W | W | W | A. L. Runion, M.D. |
| | 9 | 6 | 10 | 14 | NW | NW | NW | Theodore Day. |
| | 11 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| | 7 | 13 | 2 | 15 | . . . | . . . | . . . | J. T. Ambrose. |
| | 5 | 6 | 8 | 16 | NW | NW | NW | Benj. M. Hall. |
| | 6 | 19 | 2 | 9 | NW | NW | NW | Mrs. L. H. Grenewald. |

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

29th, 30th; Catawissa, 5th, 6th, 7th, 14th, 15th, 19th, 21st, 22d, 23d, 24th, 27th, 29th, 30th; Meadville, 5th, 13th, 14th, 24th; Carlisle, 5th, 6th, 14th, 21st, 29th, 30th; Uniontown, 5th; Huntingdon, 14th, 15th, 23d, 24th, 25th, 26th, 28th, 29th, 30th; Petersburg, 5th, 6th, 14th, 24th, 28th, 29th, 30th; Lancaster, 1st, 5th, 6th, 7th, 14th, 21st, 23d, 24th, 28th, 29th, 30th; New Castle, 3d, 4th, 5th, 6th, 13th, 14th, 15th, 20th, 21st, 23d, 24th, 26th, 27th, 28th 29th, 30th; Myerstown, 5th, 6th, 7th, 14th, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th; Coopersburg, 5th, 21st, 24th, 27th, 28th, 29th, 30th; Wilkes-Barre, 5th, 14th, 24th, 28th, 29th, 30th; Nisbet, 5th, 6th, 7th, 14th, 21st, 29th; Bethlehem, 5th, 6th, 21st, 24th, 27th, 28th, 29th, 30th; Philadelphia, 1st, 4th, 5th, 14th, 20th, 21st, 24th, 27th, 28th; Girardville, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 10th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th; Selins Grove, 3d, 5th, 6th, 7th, 14th, 21st, 23d, 24th, 26th, 27th, 28th, 29th, 30th; Somerset, 13th, 21st, 23d; Eagles Mere, 13th; Wellsboro, 1st, 4th, 5th, 6th, 7th, 12th, 13th, 14th, 15th, 20th, 21st, 22d, 23d, 24th, 26th, 27th, 28th, 29th; Lewisburg, 3d; Columbus, 1st, 3d, 4th, 5th, 12th, 13th, 14th, 15th, 20th, 21st, 22d, 23d, 24th, 26th, 27th, 28th, 29th, 30th; Dyberry, 1st, 3d, 4th, 5th, 6th, 7th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th; South Eaton, 4th, 5th, 12th, 20th, 21st, 22d, 23d, 24th, 26th, 27th, 28th, 29th, 30th; York, 4th, 6th, 7th, 21st, 24th, 29th, 30th; Indiana, 14th, 21st, 24th, 28th, 29th; Greenville, 4th, 5th, 13th, 20th, 21st, 23d, 24th.

*Sleet.*—Blue Knob, 2d; Le Roy, 19th; Rimersburg, 19th; Meadville, 19th; Nisbet, 12th; Canonsburg, 2d.

*Aurora.*—Le Roy, 7th; Westtown, 7th; Meadville, 6th; Eagles Mere, 7th, 13th.

*Coronæ.*—Charlesville, 24th; Quakertown, 16th; Eagles Mere, 21st, 22d, 24th; Dyberry, 16th, 19th; Greenville, 22d, 23d.

*Solar Halos.*—Le Roy, 14th, 29th; Meadville, 14th; Philadelphia, 7th, 8th, 25th, 26th; Eagles Mere, 14th; Dyberry, 14th.

*Lunar Halos.*—State College, 20th, 29th; West Chester, 24th, 25th; Phœnixville, 17th; Westtown, 25th; Rimersburg, 21st; Grampian Hills, 20th; Meadville, 19th, 21st, 22d, 23d; Carlisle, 21st, 23d, 24th; Lancaster, 22d, 27th; Selins Grove, 22d, 24th; Eagles Mere, 22d; Greenville, 21st.

*Meteors.*—Blue Knob, 6th, 29th; State College, 6th; Phœnixville, 7th; Westtown, 26th; Coopersburg, 10th; Honesdale, 6th, 14th; Greenville, 13th.

*Parhelias.*—Charlesville, 27th.

*Zodiacal Lights.*—Le Roy, 13th; Quakertown, 5th.

### WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for November, 1890:

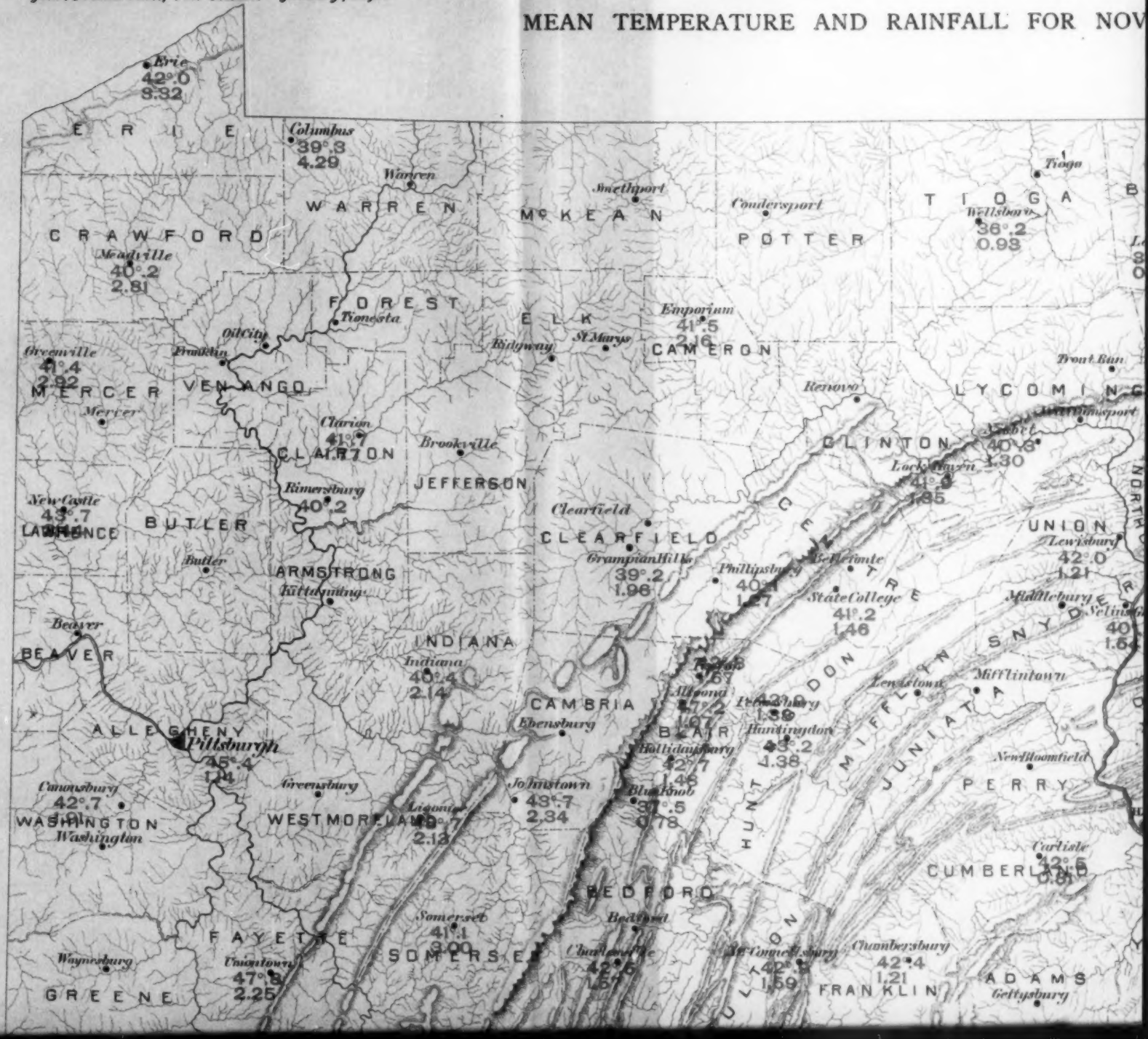
Weather, 85 per cent.
Temperature, 87 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
| Robt. M. Graham, | Catawissa. |
| Henry F. Bitner, | Millersville. |
| A. M. Wildman, | Langhorne. |
| G. W. Klee, | Chambersburg. |
| A. Simon's Sons, | Lock Haven. |
| *Raftsman's Journal*, | Clearfield. |
| R. C. Schmidt & Co., | Belle Vernon. |
| Chas. B. Lutz, | Bloomsburg. |
| E. C. Lorentz, | Johnstown. |
| W. M. James, | Ashland. |
| Miller & Allison, | Punxsutawney. |

| *Displayman.* | *Station.* |
|---|---|
| E. J. Sellers, | Kutztown. |
| C. A. Hinsdell, | Scranton. |
| H. M. Kaisinger, | Hartsville. |
| Foulk & Co., | Milford. |
| William Lawton, | Wilmington, Del. |
| Wister Heberton & Co., | Germantown. |
| Charles M. Mullen, | Bedford. |
| E. W. Merrill, | North East. |
| A. Simon's Sons, | Lock Haven. |
| Frank Ridgway, | Harrisburg. |
| G. W. Yost, | Collegeville. |
| A. C. Tryon, | Spartansburg. |
| A. H. Gerbench, | Annville. |
| Knowles Croskey, | Phoenixville. |
| Powell Bros., | Shadeland. |
| Lincoln E. Rowley, | Athens. |
| P. S. Weber, | Du Bois. |
| E. Jennet, | Franklin. |
| Milton C. Cooper, | Ashbourne. |
| J. L. Long, | Freeport. |
| J. H. Apple, | Clarion. |

# MEAN TEMPERATURE AND RAINFALL FOR NOV



AN TEMPERATURE AND RAINFALL FOR NOVEMBER.

BER. 1890.

Montrose
SUSQUEHANNA
WAYNE
Hawley
1.68
Honesdale
37°.2
1.18
Tunkhannock
South Eaton
40°.2
0.78
Scranton
WYOMING
LACKAWANNA
Bloomsburg
Milford
PIKE
Wilkesbarre
39°.0
LUZERNE
COLUMBIA
MONROE
Stroudsburg
Bloomsburg
Danville
43°.0
1.17
CARBON
Mauch Chunk
39°.0
1.00
NORTHAMPTON
Easton
Womelsdorf
40°.7
1.67
SCHUYLKILL
Pottsville
Lynnport
Bethlehem
LEHIGH
Allentown
0.32
Hamburg
Doylestown
Quakertown
0.95
40°.1
1.25
BUCKS
BERKS
LEBANON
Reading
Lebanon
40°.5
1.28
MONTGOMERY
Pottstown
44°.0
1.00
Norristown
Phoenixville
LANCASTER
CHESTER
Lancaster
43°.1
1.04
Coatesville
41°.4
1.07
Westtown
43°.2
0.97
Kennett Square
39°.8
0.83
DELAWARE
PHILADELPHIA
York
43°.2
0.80

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW.

FOR DECEMBER, 1890.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 31, 1890.

### TEMPERATURE.

The mean temperature of 55 stations for December, 1890, was 27°·5, which is over 2°·0 below the normal, and 11°·8 below the corresponding month of 1889.

The mean of the daily maxima and minima temperatures 35°·0 and 19°·4 give an average daily range of 15°·6, and a monthly mean of 27°·2.

Highest monthly mean, 33°·1 at Uniontown.

Lowest monthly mean, 20°·6 at Dyberry.

Highest temperature recorded during the month, 59°·0 on the 11th at Charlesville.

Lowest temperature, minus 11°·0 on the 29th at Dyberry.

Greatest local monthly range, 25°·2 at Wilkes-Barre.

Least local monthly range, 11°·1 at Grampian Hills.

Greatest daily range, 40° at Somerset on the 20th and Honesdale on the 29th.

Least daily range, 1° at Catawissa and Petersburg on the 7th.

From January 1, 1890, to December 31, 1890, the excess in temperature at Philadelphia was 682°, at Erie 47° and at Pittsburgh 752°.

The coldest period of the month was on the 20th and 31st.

### BAROMETER.

The mean pressure for the month, 30·09, is about ·03 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·62 at Harris-

burg and Philadelphia on the 20th, and the lowest 29·42 at Philadelphia on the 17th.

### PRECIPITATION.

The average precipitation 3·97 inches for the month, is an excess of 1·00 inch.

It was largely composed of snow.

The largest totals in inches were Blue Knob, 9·68; Eagles Mere, 7·02; Uniontown, 6·84; Indiana, 6·51; Phillipsburg, 5·94; Le Roy, 5·78; Hollidaysburg, 5·71; Pittsburgh, 5·64; Somerset, 5·52; and Dyberry, 5·29.

The least were Erie, 1·72; New Castle, 2·13; Columbus, 2·16; and Philadelphia, 2·33.

The following are the largest totals of snow fall reported: Blue Knob, 99 inches; Eagles Mere, 65 inches; Somerset, 60 inches; Le Roy, 57 inches; Indiana, 50 inches; and Wellsboro, 49 inches.

The heaviest snows occurred on the 17th and 26th. A considerable quantity remained on the ground at the end of the month.

### WIND AND WEATHER.

The prevailing wind was from the Northwest. The storms of the 17th and 26th were quite heavy. Considerable damage was done by wind, and travel in some parts of the state was delayed by snow drifts.

A large storage of ice was harvested during the month.

Average number: Rainy days, 12; clear days, 7; fair days, 8; cloudy days, 16.

Errata: Coopersburg mean temperature for October should be 51·3 instead of 53·3.

### MISCELLANEOUS PHENOMENA.

*Hail.*—Forks of Neshaminy, 3d; Emporium, 31st; Phœnixville, 26th; Wellsboro, 31st; Dyberry, 3d, 6th; York, 17th.

*Snow.*—Charlesville, 2d, 4th, 8th, 12th, 16th, 17th, 18th, 25th, 26th, 27th, 29th; Blue Knob, 1st, 2d, 3d, 4th, 5th, 8th, 11th, 12th, 13th, 16th, 17th, 18th, 23d, 24th, 25th, 26th, 27th, 28th, 29th; Hollidaysburg, 1st, 2d, 3d, 8th, 12th, 16th, 17th, 18th, 25th, 26th, 27th, 29th; Wysox, 1st, 2d, 8th, 11th, 16th, 17th, 23d, 26th, 31st; Le Roy, 1st, 3d, 4th, 5th, 8th, 12th, 17th, 18th, 23d, 25th, 26th, 27th, 28th, 29th; Forks of Neshaminy, 1st, 3d, 8th, 10th, 26th, 29th; Quakertown, 1st, 3d, 8th, 10th, 12th, 13th, 16th, 18th, 26th, 27th, 29th; Johnstown, 1st, 3d, 8th, 12th, 16th, 17th, 24th, 25th, 26th, 27th, 29th; Emporium, 1st, 3d, 4th, 5th, 6th, 10th, 13th, 17th, 26th, 27th, 28th, 29th; State College, 1st, 3d, 5th, 8th, 10th, 12th, 16th, 17th, 18th, 23d, 26th, 29th; Phillipsburg, 1st, 3d, 5th, 8th, 12th, 16th, 17th, 25th, 26th, 28th, 29th; Coatesville, 1st, 2d, 3d, 5th, 8th, 16th, 26th, 27th, 29th; Kennett Square, 10th, 26th, 29th; Phœnixville, 1st, 2d, 8th, 18th, 26th, 29th; Westtown, 2d, 3d, 8th, 10th, 25th, 26th, 29th; Rimersburg, 1st, 2d, 3d, 4th, 5th, 8th, 10th, 12th, 16th, 17th, 24th, 26th, 27th,

# Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service

| County. | Station. | Elevation above Sea Level (feet). | Barometer Reduced to Sea Level. | | | Temperature. | | | | | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maximum. | | Minimum | | | | Daily Range. | | | | | | | | | | |
| | | | Mean. | Highest. | Lowest. | Mean. | Highest. | Date. | Lowest. | Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow |
| Allegheny,[1] | Pittsburgh, | 847 | 30·120 | 30·340 | 29·630 | 32·1 | 52 | 11 | 16 | 20 | 37·8 | 26·4 | 11·4 | 26·0 | 20 | 4·0 | 25 | | 76·6 | 25·2 | 5·64 | 41·30 | . |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 27·4 | 59 | 11 | — 5 | 20 | 36·5 | 17·5 | 19·0 | 38·0 | 30 | 4·0 | 17 | | 79·0 | 21·5 | 3·83 | 35·50 | 14 |
| Blair,[2] | Altoona (30 days), | 1,181 | . . . | . . . | . . . | 34·5 | 56 | 12 | 14 | 20 | 42·5 | 26·4 | 16·1 | 29·0 | 12 | 8·0 | 11 | | 70·7 | 26·0 | 3·80 | . . . | . |
| Blair, | Blue Knob, | 2,500 | . . . | . . . | . . . | 23·4 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | 9·68 | 96·50 | 36 |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 28·4 | 57 | 11 | — 2 | 20 | 36·4 | 18·2 | 18·2 | 30·0 | 21 | 8·0 | 17 | | 75·4 | 21·5 | 5·71 | 36·75 | 10 |
| Blair, | Tipton, | 915 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Bradford, | Wysox, | 718 | 30·110 | 30·602 | 29·574 | 23·7 | 43 | 21, 23 | — 9 | 20 | 30·3 | 14·0 | 16·3 | 36·5 | 29 | 5·0 | 18 | | 76·7 | 17·6 | 3·48 | 29·50 | 24 |
| Bradford, | Le Roy, | 1,400 | . . . | . . . | . . . | 22·5 | 40 | 11, 23 | 0 | 20 | 28·0 | 16·4 | 11·6 | 25·0 | 20 | 2·0 | 18 | | . . . | . . . | 5·78 | 57·10 | 24 |
| Bucks, | Forks of Neshaminy, | . . . | . . . | . . . | . . . | 30·4 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | 2·51 | . . . | . |
| Bucks, | Quakertown, | 536 | 30·090 | 30·690 | 29·530 | 27·0 | 52 | 11 | 5 | 31 | 36·5 | 17·6 | 18·9 | 28·3 | 29 | 8·2 | 18 | | 76·6 | 20·6 | 3·21 | 8·60 | 6 |
| Cambria,[1] | Johnstown, | 1,184 | 30·160 | 30·610 | 29·650 | 29·9 | 51 | 11 | 7 | 20 | 37·9 | 21·9 | 16·0 | 28·0 | 20 | 5·0 | 17 | | 83·3 | 23·9 | 4·89 | 42·00 | 16 |
| Cameron, | Emporium, | 1,030 | . . . | . . . | . . . | 27·4 | 48 | 11 | 7 | 20 | 35·2 | 15·3 | 19·9 | 33·0 | 20 | 6·0 | 1 | | . . . | . . . | 3·21 | 31·25 | 6 |
| Carbon,[1] | Mauch Chunk (29 days), | 550 | . . . | . . . | . . . | 27·1 | 48 | 23 | 4 | 29 | 36·0 | 18·2 | 17·8 | 31·0 | 29 | 9·0 | 27 | | . . . | . . . | 3·18 | . . . | . |
| Centre, | State College—<br>Agricultural Experiment Station, | 1,191 | 30·059 | 30·611 | 29·510 | 25·9 | 48 | 11 | 1 | 20 | 32·3 | 17·5 | 14·8 | 29·0 | 21 | 4·0 | 17 | | 86·7 | 21·8 | 3·19 | 32·63 | 11 |
| Centre, | Phillipsburg, | 1,350 | . . . | . . . | . . . | 24·0 | 50 | 11 | — 8 | 18 | 34·2 | 15·0 | 19·2 | 38·0 | 18 | 8·0 | 3 | | . . . | . . . | 5·94 | 51·30 | 25 |
| Chester, | West Chester, | 455 | 30·047 | 30·355 | 29·394 | 29·9 | 51 | 23 | 14 | 26 | 37·1 | 22·9 | 14·2 | 21·5 | 3 | 5·0 | 8 | | 68·0 | 21·0 | 3·94 | 11·00 | 3 |
| Chester, | Coatesville, | 380 | . . . | . . . | . . . | 28·3 | 53 | 23 | 7 | 30 | 38·5 | 19·4 | 19·1 | 32·0 | 11 | 7·0 | 8 | | . . . | . . . | 3·51 | 12·69 | 6 |
| Chester,[1] | Kennett Square, | 275 | . . . | . . . | . . . | 29·1 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | 3·37 | 8·25 | . |
| Chester, | Phœnixville, | 183 | 30·375 | 30·606 | 29·432 | 30·7 | 54 | 23 | 10 | 31 | 38·1 | 23·3 | 14·8 | 23·0 | 14 | 4·0 | 8 | | 76·7 | 21·7 | 2·67 | 8·35 | 4 |
| Chester, | Westtown, | 350 | 30·114 | 30·544 | 29·575 | 31·7 | 50 | 23 | 13 | 31 | 36·9 | 24·5 | 12·4 | 23·5 | 3 | 3·0 | 8 | | . . . | . . . | 3·30 | 12·00 | 6 |
| Clarion, | Rimersburg, | 1,500 | . . . | . . | . . . | 25·9 | 46 | 19 | 0 | 20 | 30·6 | 20·9 | 9·7 | 37·0 | 20 | 2·0 | 31 | | . . . | . . . | . . . | 45·00 | 15 |
| Clarion, | Clarion—<br>State Normal School, | 1,530 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 24·0 | 44 | 11 | 5 | 20 | 29·6 | 18·5 | 11·1 | 28·0 | 20 | 4·0 | 18 | | . . . | . . . | 4·28 | 43·00 | 24 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | 26·6 | 50 | 11 | 0 | 20 | 32·2 | 17·3 | 14·9 | 28·0 | 31 | 6·0 | 18 | | . . . | . . . | 4·43 | 42·80 | 16 |
| Columbia, | Catawissa (28 days), | 491 | . . . | . . . | . . . | 28·5 | 45 | 11 | 10 | 2, 20 | 33·1 | 21·8 | 11·3 | 20·0 | 23 | 1·0 | 7 | | . . . | . . . | 4·30 | 32·00 | 12 |
| Crawford, | Meadville, | 1,320 | 30·110 | 30·590 | 29·550 | 26·5 | 43 | 22 | 8 | 20, 30 | 32·4 | 19·5 | 12·9 | 33·0 | 20 | 6·0 | 21 | | 84·0 | 21·3 | 3·10 | 29·25 | 6 |
| Cumberland, | Carlisle, | 480 | . . . | . . . | . . . | 28·6 | 56 | 11 | 8 | 30, 31 | 35·6 | 20·3 | 15·3 | 26·0 | 30 | 5·0 | 1 | | 86·0 | 24·0 | 4·20 | 23·00 | 10 |
| Dauphin,[1] | Harrisburg, | 361 | 30·072 | 30·618 | 29·526 | 29·2 | 55 | 11 | 14 | 26, 31 | 35·3 | 23·6 | 11·7 | 23·0 | 11 | 4·0 | 24 | | 77·8 | 22·8 | 2·42 | 15·00 | 7 |
| Delaware, | Swarthmore—<br>Swarthmore College, | 190 | 30·035 | 30·540 | 29·578 | 30·7 | 51 | 23 | 15 | 2 | 38·2 | 25·2 | 13·0 | 27·5 | 14 | 2·0 | 8 | | 81·0 | 25·0 | 2·49 | 8·50 | 8 |
| Erie,[1] | Erie, | 681 | 30·050 | 30·550 | 29·510 | 29·0 | 51 | 22 | 9 | 28 | 36·0 | 22·0 | 14·0 | 26·0 | 20 | 5·0 | 19 | | 76·0 | 21·0 | 1·72 | . . . | . |
| Fayette, | Uniontown, | 1,000 | 30·047 | 30·426 | 29·552 | 33·1 | 53 | 11, 24 | 9 | 20 | 39·2 | 26·3 | 12·9 | 35·0 | 20 | 1·0 | 21 | | . . . | . . . | 6·84 | 24·50 | . |
| Franklin,[2] | Chambersburg—<br>Wilson Female College (28 days), | 618 | 30·129 | 30·529 | 29·663 | 27·6 | 58 | 11 | 5 | 30 | 37·3 | 18·0 | 19·3 | 35·0 | 11 | 4·0 | 7 | | 85·0 | 23·3 | . . . | . . . | . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 29·4 | 58 | 11 | 6 | 28, 29 | 38·0 | 20·3 | 18·3 | 32·0 | 29 | 5·0 | 17 | | 75·8 | 26·4 | 3·30 | 26·00 | 12 |
| Huntingdon,[1] | Huntingdon—<br>The Normal College, | 650 | . . . | . . . | . . . | 28·9 | 52 | 11 | 5 | 20 | 37·3 | 20·5 | 16·8 | 30·0 | 21 | 4·0 | 17 | | . . . | . . . | 3·35 | 33·50 | 12 |
| Huntingdon, | Petersburg, | 700 | . . . | . . . | . . . | 29·4 | 58 | 11 | 4 | 20 | 36·2 | 23·9 | 12·3 | 24·0 | 30 | 1·0 | 7 | | . . . | . . . | 3·91 | 25·00 | 15 |
| Indiana, | Indiana—<br>State Normal School, | 1,350 | 30·096 | 30·382 | 29·636 | 27·4 | 47 | 11 | 7 | 28 | 33·9 | 18·8 | 15·1 | 31·0 | 20 | 5·0 | 12 | | 85·8 | 24·0 | 6·51 | 49·75 | 14 |
| Lancaster, | Lancaster (28 days), | 411 | 30·070 | 30·353 | 29·616 | 31·4 | 56 | 11 | 9 | 3 | 41·1 | 22·3 | 18·6 | 30·5 | 14 | 8·5 | 18 | | 77·6 | 28·6 | 1·08 | . . . | . |
| Lawrence, | New Castle, | 932 | . . . | . . . | . . . | 29·8 | 45 | 11, 23 | 2 | 20 | 35·3 | 18·6 | 16·7 | 38·0 | 20 | 7·0 | 18 | | 87·8 | 27·4 | 2·13 | 16·95 | . |
| Lebanon, | Myerstown (30 days), | 474 | 30·082 | 30·502 | 29·596 | 28·2 | 52 | 11 | 1 | 2 | 37·7 | 18·8 | 18·9 | 27·8 | 2 | 7·5 | 18 | | 80·5 | 22·0 | 3·98 | 14·00 | 5 |
| Lehigh, | Coopersburg, | 520 | . . . | . . . | . . . | 28·2 | 53 | 11 | 11 | 30 | 39·0 | 21·1 | 17·9 | 29·0 | 20 | 9·0 | 18 | | . . . | . . . | 3·76 | 9·50 | 4 |
| Lehigh,[1] | Lynnport, | 350 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Luzerne, | Drifton—<br>Drifton Hospital, | 1,655 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . . | . . . | . . . | 23·5 | 48 | 1 | — 9 | 29 | 36·1 | 10·9 | 25·2 | 38·0 | 28 | 14·0 | 11 | | . . . | . . . | 3·95 | 19·80 | . |
| Lycoming,[1] | Nisbet, | 550 | . . . | . . . | . . . | 26·1 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | 4·45 | 33·00 | 21 |
| McKean, | Smethport (30 days), | 1,500 | . . . | . . . | . . . | 24·5 | 44 | 11 | — 7 | 8, 20 | 32·0 | 15·1 | 16·9 | 33·0 | 20 | 8·0 | 17 | | . . . | . . . | . . . | 31·50 | . |
| Mercer,[1] | Greenville—<br>Thiel College, | 1,000 | 30·053 | 30·601 | 29·538 | 26·6 | 50 | 31 | 1 | 30 | 34·6 | 18·9 | 15·7 | 37·7 | 30 | 5·0 | 1 | | 92·3 | 22·8 | 2·68 | 24·50 | 3 |
| Mifflin, | Pottstown, | 150 | . . . | . . | . . . | 29·7 | 53 | 11 | 12 | 2 | 37·3 | 23·8 | 13·5 | 24·0 | 11 | 5·0 | 8 | | 75·0 | 23·0 | 2·86 | 9·50 | 3 |
| Northampton, | Bethlehem, | 360 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Philadelphia,[1] | Philadelphia—<br>Signal Office, | 117 | 30·098 | 30·620 | 29·420 | 32·2 | 52 | 12 | 17 | 26 | 38·3 | 26·0 | 12·3 | 26·0 | 3 | 5·0 | 28 | | 69·0 | 22·0 | 2·34 | 6·05 | 2 |
| Schuylkill, | Girardville, | 1,000 | 30·061 | 30·452 | 29·617 | 27·5 | 46 | 11 | 10 | 2 | 35·6 | 20·2 | 15·4 | 27·0 | 23 | 8·0 | 18 | | . . . | . . . | 4·65 | 23·75 | 18 |
| Snyder, | Selins Grove (28 days), | 445 | . . . | . . . | . . . | 28·2 | 47 | 15 | 6 | 20 | 35·9 | 20·5 | 15·4 | . . . | . . . | . . . | . . . | | 80·9 | 24·8 | 4·38 | 21·00 | 5 |
| Somerset, | Somerset, | 2,250 | . . . | . . . | . . . | 26·8 | 50 | 11 | 1 | 20 | 33·2 | 16·7 | 16·5 | 40·0 | 20 | 6·0 | 17 | | 81·1 | 21·1 | 5·52 | 60·00 | 36 |
| Sullivan, | Eagles Mere, | 2,060 | 30·139 | 30·686 | 29·7·0 | 22·1 | 38 | 23,24,25 | — 4 | 13 | 27·7 | 16·2 | 11·5 | 20·0 | 21 | 4·0 | 31 | | 73·1 | 15·0 | 7·02 | 65·25 | 30 |
| Tioga, | Wellsboro, | 1,327 | 30·070 | 30·649 | 29·549 | 22·2 | 45 | 11 | —10 | 20 | 30·1 | 15·3 | 14·8 | 24·0 | 9 | 2·0 | 17 | | 80·6 | 17·5 | 4·97 | 48·85 | 36 |
| Union,[1] | Lewisburg, | 450 | . . . | . . . | . . . | 27·8 | 48 | 11 | 6 | 31 | 36·3 | 19·4 | 16·9 | 30·0 | 21 | 8·0 | 17 | | . . . | . . . | 2·99 | 22·90 | 6 |
| Warren, | Columbus, | 1,410 | . . . | . . . | . . . | 24·2 | 44 | 20, 22 | — 4 | 30 | 31·3 | 17·1 | 14·2 | 44·0 | 20 | 2·0 | 4 | | 68·0 | 15·0 | 2·16 | . . . | 12 |
| Washington, | Canonsburg, | 950 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | | . . . | . . . | . . . | . . . | . |
| Wayne, | Dyberry, | 1,100 | . . . | . . . | . . . | 20·6 | 43 | 11 | —11 | 29 | 29·4 | 11·0 | 18·4 | 38·0 | 29 | 6·0 | 18 | | . . . | . . . | 5·29 | 35·50 | 25 |
| Wayne, | Honesdale, | 1,000 | . . . | . . . | . . . | 22·1 | 45 | 11 | — 9 | 29 | 29·9 | 14·3 | 15·6 | 40·0 | 29 | 4·0 | 22 | | . . . | . . . | 4·01 | 20·00 | 14 |
| Westmoreland, | Ligonier (27 days), | 1,750 | . . . | . . . | . . . | 29·9 | 52 | 11 | 4 | 20 | 35·6 | 18·8 | 16·8 | 36·0 | 30 | 6·0 | 1 | | . . . | . . . | 3·69 | 22·30 | . |
| Wyoming,[1] | South Eaton | 660 | . . . | . . . | . . . | 25·6 | 47 | 11 | — 3 | 28, 29 | 34·3 | 16·9 | 17·4 | 35·0 | 29 | 4·0 | 17 | | . . . | . . . | 3·31 | 24·00 | 15 |
| York,[1] | York, | 385 | 30·036 | 30·431 | 29·547 | 29·8 | 56 | 11 | 6 | 30 | 38·0 | 21·0 | 17·6 | 28·0 | 14 | 7·5 | 17 | | 85·2 | 23·9 | 3·29 | 18·50 | 5 |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

# Voluntary Observers of the Pennsylvania State Weather Service for Dec

| Temperature. | | | | | | | | | | | Precipitation. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nimum | | | Daily Range. | | | | | | | | | | | |
| Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | Relative Humidity. | Dew Point. | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at End of Month. | Number of Days Rainfall. |
| 20 | 37·8 | 26·4 | 11·4 | 28·0 | 20 | 4·0 | 25 | 76·8 | 25·2 | 5·64 | 41·30 | . . . | 18 |
| 20 | 36·5 | 17·5 | 19·0 | 38·0 | 30 | 4·0 | 17 | 79·0 | 21·5 | 3·83 | 35·50 | 14·00 | 12 |
| 20 | 42·5 | 26·4 | 16·1 | 29·0 | 12 | 8·0 | 11 | 70·7 | 26·0 | 3·80 | . . . | . . . | 13 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 9·68 | 96·50 | 36·50 | 17 |
| 20 | 36·4 | 18·2 | 18·2 | 30·0 | 21 | 8·0 | 17 | 75·4 | 21·5 | 5·71 | 36·75 | 10·00 | 14 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 20 | 30·3 | 14·0 | 16·3 | 36·5 | 29 | 5·0 | 18 | 76·7 | 17·6 | 3·48 | 29·50 | 24·00 | 11 |
| 20 | 28·0 | 16·4 | 11·6 | 25·0 | 20 | 2·0 | 18 | . . . | . . . | 5·78 | 57·10 | 24·00 | 14 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·51 | . . . | . . . | 13 |
| 31 | 36·5 | 17·6 | 18·9 | 28·3 | 29 | 8·3 | 18 | 76·6 | 20·6 | 3·21 | 8·60 | 6·00 | 11 |
| 20 | 37·9 | 21·9 | 16·0 | 28·0 | 20 | 5·0 | 17 | 83·3 | 23·9 | 4·89 | 42·00 | 16·00 | 19 |
| 20 | 35·2 | 15·3 | 19·9 | 33·0 | 20 | 6·0 | 1 | . . . | . . . | 3·21 | 31·25 | 6·00 | 9 |
| 29 | 36·0 | 18·2 | 17·8 | 31·0 | 29 | 9·0 | 27 | . . . | . . . | 3·18 | . . . | . . . | 7 |
| 20 | 32·3 | 17·5 | 14·8 | 29·0 | 21 | 4·0 | 17 | 86·7 | 21·8 | 3·19 | 32·65 | 11·00 | 11 |
| 18 | 34·2 | 15·0 | 19·2 | 38·0 | 18 | 8·0 | 3 | . . . | . . . | 5·94 | 51·50 | 25·00 | 17 |
| 26 | 37·1 | 22·9 | 14·2 | 21·5 | 3 | 5·0 | 8 | 68·0 | 21·0 | 3·94 | 11·00 | 3·00 | 13 |
| 30 | 38·5 | 19·4 | 19·1 | 32·0 | 11 | 7·0 | 8 | . . . | . . . | 3·51 | 12·69 | 6·00 | 13 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 3·37 | 8·25 | . . . | 8 |
| 31 | 38·1 | 23·3 | 14·8 | 23·0 | 14 | 4·0 | 8 | 76·7 | 21·7 | 2·07 | 8·35 | 4·75 | 13 |
| 31 | 36·0 | 24·5 | 12·4 | 23·5 | 3 | 3·0 | 8 | . . . | . . . | 3·30 | 12·00 | 6·00 | 6 |
| 20 | 30·6 | 20·9 | 9·7 | 37·0 | 20 | 2·0 | 31 | . . . | . . . | . . . | 45·00 | 15·00 | 17 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 20 | 29·6 | 18·5 | 11·1 | 28·0 | 20 | 4·0 | 18 | . . . | . . . | 4·28 | 43·00 | 24·00 | 14 |
| 20 | 32·2 | 17·3 | 14·9 | 28·0 | 31 | 6·0 | 18 | . . . | . . . | 4·43 | 42·80 | 16·00 | 14 |
| 2, 20 | 33·1 | 21·8 | 11·3 | 20·0 | 23 | 1·0 | 7 | . . . | . . | 4·10 | 32·00 | 12·00 | 10 |
| 20, 30 | 32·4 | 19·5 | 12·9 | 33·0 | 20 | 6·0 | 21 | 84·0 | 21·3 | 3·10 | 29·25 | 6·00 | 14 |
| 30, 31 | 35·6 | 20·3 | 15·3 | 26·0 | 30 | 5·0 | 1 | 86·0 | 24·0 | 4·20 | 23·00 | 10·00 | 13 |
| 26, 31 | 35·3 | 23·6 | 11·7 | 23·0 | 11 | 4·0 | 24 | 77·8 | 22·8 | 2·42 | 15·00 | 7·00 | 12 |
| 2 | 38·2 | 25·2 | 13·0 | 27·5 | 14 | 2·0 | 8 | 81·0 | 25·0 | 2·49 | 8·50 | 8·00 | 6 |
| 28 | 36·0 | 22·0 | 14·0 | 26·0 | 20 | 5·0 | 19 | 76·0 | 21·0 | 1·72 | . . | . . . | 18 |
| 20 | 39·2 | 26·3 | 12·9 | 35·0 | 20 | 1·0 | 21 | . . . | . . . | 6·84 | 24·30 | . . . | 18 |
| 30 | 37·3 | 18·0 | 19·3 | 35·0 | 11 | 4·0 | 7 | 83·9 | 23·3 | . . . | . . . | . . . | . . . |
| 28, 29 | 38·6 | 20·3 | 18·3 | 32·0 | 29 | 5·0 | 17 | 73·8 | 26·4 | 3·30 | 26·00 | 12·00 | 5 |
| 20 | 37·3 | 20·5 | 16·8 | 30·0 | 21 | 4·0 | 17 | . . . | . . . | 3·35 | 33·50 | 12·00 | 5 |
| 20 | 36·2 | 23·9 | 12·3 | 24·0 | 30 | 1·0 | 7 | . . . | . . . | 3·91 | 25·00 | 15·00 | 9 |
| 28 | 33·9 | 18·8 | 15·1 | 31·0 | 20 | 5·0 | 12 | 85·8 | 24·0 | 6·51 | 49·75 | 14·00 | 7 |
| 3 | 41·1 | 22·5 | 18·6 | 30·5 | 14 | 8·5 | 18 | 77·6 | 28·6 | 1·08 | . . . | . . . | 5 |
| 20 | 35·3 | 18·6 | 16·7 | 38·0 | 20 | 7·0 | 18 | 87·8 | 27·4 | 2·13 | 16·95 | . . . | 11 |
| 2 | 37·7 | 18·8 | 18·9 | 27·8 | 2 | 7·5 | 18 | 80·5 | 22·0 | 3·98 | 14·00 | 5·00 | 11 |
| 30 | 39·0 | 21·1 | 17·9 | 29·0 | 20 | 9·0 | 18 | . . . | . . . | 3·76 | 9·50 | 4·00 | 14 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 29 | 36·1 | 10·9 | 25·2 | 38·0 | 28 | 14·0 | 11 | . . . | . . . | 3·95 | 19·80 | . . . | 10 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·45 | 33·00 | 21·00 | 10 |
| 8, 20 | 32·0 | 15·1 | 16·9 | 33·0 | 20 | 8·0 | 17 | . . . | . . . | . . . | 31·50 | . . . | . . . |
| 30 | 34·6 | 18·9 | 15·7 | 37·7 | 30 | 5·0 | 1 | 92·3 | 22·8 | 2·68 | 24·50 | 3·00 | 18 |
| 2 | 37·3 | 23·8 | 13·5 | 24·0 | 11 | 5·0 | 8 | 75·0 | 23·0 | 2·86 | 9·50 | 3·00 | 6 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 26 | 38·3 | 26·0 | 12·3 | 26·0 | 3 | 5·0 | 28 | 69·0 | 22·0 | 2·33 | 6·05 | 2·60 | 13 |
| 2 | 35·6 | 20·2 | 15·4 | 27·0 | 23 | 8·0 | 18 | . . . | . . . | 4·65 | 23·75 | 18·00 | 13 |
| 20 | 35·9 | 20·5 | 15·4 | . . . | . . . | . . . | . . . | 80·9 | 24·8 | 4·38 | 21·00 | 5·75 | 7 |
| 20 | 33·2 | 16·7 | 16·5 | 40·0 | 20 | 6·0 | 17 | 81·1 | 21·1 | 5·52 | 60·00 | 36·00 | 15 |
| 13 | 27·7 | 16·2 | 11·5 | 20·0 | 21 | 4·0 | 31 | 73·1 | 15·0 | 7·02 | 65·25 | 39·00 | 13 |
| 20 | 30·1 | 15·3 | 14·8 | 24·0 | 9 | 2·0 | 17 | 80·6 | 17·5 | 4·97 | 48·85 | 36·25 | 13 |
| 31 | 36·3 | 19·4 | 16·9 | 30·0 | 21 | 8·0 | 17 | . . . | . . . | 2·99 | 22·90 | 6·00 | 8 |
| 30 | 31·3 | 17·1 | 14·2 | 44·0 | 20 | 2·0 | 4 | 68·0 | 15·0 | 2·16 | . . . | 12·00 | 16 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 29 | 29·4 | 11·0 | 18·4 | 38·0 | 29 | 6·0 | 18 | . . . | . . . | 5·29 | 35·50 | 25·00 | 10 |
| 29 | 29·9 | 14·3 | 15·6 | 42·0 | 29 | 4·0 | 22 | . . . | . . . | 4·01 | 20·00 | 14·00 | 11 |
| 20 | 35·6 | 18·8 | 16·8 | 36·0 | 30 | 6·0 | 1 | . . . | . . . | 3·69 | 22·30 | . . | 8 |
| 28, 29 | 34·3 | 16·9 | 17·4 | 35·0 | 29 | 4·0 | 17 | . . . | . . . | 3·31 | 24·00 | 15·00 | 13 |
| 30 | 38·0 | 21·0 | 17·6 | 28·0 | 14 | 7·5 | 17 | 85·2 | 23·9 | 3·29 | 18·50 | 5·00 | 10 |

| TION. | | NUMBER OF DAYS. | | | WIND. | | | OBSERVERS. |
|---|---|---|---|---|---|---|---|---|
| | | | | | PREVAILING DIRECTION. | | | |
| on Ground at End of Month. | Number of Days Rainfall. | Clear. | Fair. | Cloudy. | 7 A. M. | 2 P. M. | 9 P. M. | |
| . . | 18 | 4 | 8 | 19 | W | W | W | Oscar D. Stewart, Sgt. Sig. Corps, |
| 4'00 | 12 | 6 | 12 | 13 | N | SW | N | Miss E. A. G. Apple. |
| . . | 23 | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| 5'50 | 27 | 6 | 7 | 18 | NW | NW | NW | A. H. Boyle. |
| 5'00 | 14 | 10 | 6 | 15 | NW | W | W | Prof. J. A. Stewart. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Miss Cora J. Wilson. |
| 4'00 | 11 | 8 | 2 | 21 | NW | NW | NW | Charles Beecher. |
| 4'00 | 14 | 5 | 5 | 21 | SW | SW | SW | Geo. W. T. Warburton |
| . . | 13 | 11 | 10 | 10 | N | N | W | J. C. Hilsman. |
| 5'00 | 11 | 7 | 13 | 11 | NE | NW | NW | J. L. Heacock. |
| 5'00 | 19 | 5 | 8 | 18 | S | S | S | E. C. Lorentz. |
| 5'00 | 9 | 5 | 5 | 21 | NW | NW | W | T. B. Lloyd. |
| . . | 7 | 10 | 11 | 10 | NW | NW | NW | John J. Boyd. |
| 2'00 | 11 | 3 | 11 | 17 | W | W | W | Prof. Wm. Frear. |
| 5'00 | 17 | . . . | . . . | . . . | NW | NW | NW | Geo. H. Dunkle. |
| 3'00 | 13 | 14 | 5 | 12 | NW | NW | NW | Jesse C. Green, D.D.S. |
| 5'00 | 13 | 11 | 7 | 13 | W | W | W | W. T. Gordon. |
| . . | 8 | 12 | 6 | 13 | NW | NW | NW | Benj. P. Kirk. |
| 4'75 | 13 | 9 | 6 | 16 | NW | NW | NW | Knowles Croskey. |
| 6'00 | 6 | 10 | 10 | 11 | NW | NW | NW | Prof. Wm. F. Wickersham. |
| 5'00 | 17 | 4 | 5 | 22 | W | W | W | Rev. W. W. Deatrick, A.M. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | C. M. Thomas, B.S. |
| 4'00 | 14 | 4 | 10 | 17 | W | W | W | Nathan Moore. |
| 7'00 | 14 | 6 | 3 | 22 | W | W | W | Prof. John A. Robb. |
| 2'00 | 10 | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| 5'00 | 14 | 3 | 11 | 17 | S | S | W | J. & B. H. Metcalf. |
| 2'00 | 15 | 7 | 15 | 9 | N | W | NW | J. E. Pague. |
| 5'00 | 12 | 10 | 8 | 13 | W | W | W | Frank Ridgway, Sgt. Sig. Corps. |
| 8'00 | 6 | 3 | 12 | 16 | N | NW | NW | Prof. Susan J. Cunningham. |
| . . | 18 | 3 | 4 | 24 | SW | SW | SW | Peter Wood, Sgt Sig. Corps. |
| . . | 18 | 9 | 11 | 11 | W | W | W | Wm. Hunt. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Miss Mary A. Ricker. |
| 2'00 | 5 | 13 | 8 | 10 | N | W | N | Thomas F. Sloan. |
| 2'00 | 5 | 7 | 10 | 14 | W | W | W | Prof. W. J. Swigart. |
| 5'00 | 9 | 7 | 11 | 13 | NW | W | N | J. E. Rooney. |
| 4'00 | 7 | 6 | 6 | 19 | NW | SW | NW | Prof. S. C. Schmucker. |
| . . | 5 | 2 | 10 | 6 | NW | NW | NW | Lewis T. Lamps. |
| . . | 11 | 4 | 9 | 18 | NW | NW | NW | Wm. T. Butz. |
| 5'00 | 11 | 12 | 2 | 17 | W | W | W | Wm. H. Kline. |
| 4'00 | 14 | 13 | 4 | 14 | NW | SW | NW | M. H. Boye. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | John C. Wuchter. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| . . | 10 | 11 | 1 | 19 | N | . . . | SW | A. W Betterly. |
| 1'00 | 10 | 11 | . . | 20 | . . . | . . . | . . . | John S. Gibson, P. M. |
| . . | . . . | 6 | 5 | 19 | SW | SW | SW | Armstrong & Brownell. |
| 3'00 | 18 | 4 | 3 | 24 | S | S | S | Prof S. H. Miller. |
| 3'00 | 6 | 16 | 5 | 10 | W | W | W | Charles Moore, D.D.S. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Lerch & Rice. |
| 2'60 | 13 | 9 | 7 | 15 | NW | NW | NW | Luther M. Dey, Sgt. Sig. Corps. |
| 8'00 | 13 | 11 | 12 | 8 | W | W | W | E. C Wagner. |
| 5'75 | 7 | 2 | 18 | 8 | NW | NW | NW | J. M. Boyer, |
| 6'00 | 15 | . . . | 12 | 19 | NW | NW | NW | W. M. Schrock. |
| 9'00 | 13 | 7 | 7 | 17 | SW | SW | SW | E. S. Chase. |
| 6'25 | 13 | 1 | 5 | 25 | NW | NW | NW | H. D. Deming. |
| 6'00 | 8 | 9 | 11 | 11 | SW | SW | SW | F. O. Whitman. |
| 2'00 | 16 | 2 | 6 | 23 | SW | SW | SW | Wm. Loveland. |
| . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | A. L. Runion, M.D. |
| 5'00 | 10 | 5 | 10 | 16 | NW | NW | NW | Theodore Day. |
| 4'00 | 11 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| . . | 8 | 9 | 4 | 18 | . . . | . . . | . . . | J. T. Ambrose. |
| 5'00 | 13 | 4 | 9 | 18 | NW | NW | NW | Benj. M. Hall. |
| 5'00 | 10 | 16 | 3 | 12 | NW | NW | NW | Mrs. L. H. Grenewald. |

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

28th, 29th; Grampian Hills, 16th, 20th, 31st; Lock Haven, 1st, 2d, 3d, 8th, 10th, 16th, 17th, 18th, 26th, 27th, 29th; Catawissa, 1st, 3d, 10th, 17th, 26th, 27th, 29th; Meadville, 1st, 2d, 3d, 4th, 5th, 12th, 13th, 16th, 17th, 23d, 24th, 26th, 27th, 28th, 29th; Carlisle, 3d, 8th, 17th, 26th, 29th; Harrisburg, 1st, 3d; 8th, 16th, 17th, 25th, 26th, 28th, 29th, 31st; Swarthmore, 2d, 26th, 29th; Uniontown, 8th, 17th, 18th, 26th, 27th; McConnellsburg, 1st, 8th, 17th, 26th; Huntingdon, 1st, 8th, 17th, 18th, 25th, 26th; Petersburg, 1st, 3d, 8th, 16th, 17th, 18th, 25th, 26th, 27th, 28th, 29th; Indiana, 1st, 2d, 8th, 12th, 16th, 17th, 18th, 26th, 27th, 28th, 29th; Lancaster, 3d, 8th, 10th, 16th, 18th; New Castle, 2d, 4th, 8th, 12th, 17th, 26th, 27th, 28th; Myerstown, 1st, 3d, 8th, 10th, 16th, 17th, 26th, 27th, 29th; Coopersburg, 1st, 8th, 10th, 26th, 29th; Wilkes-Barre, 1st, 3d, 8th, 17th, 18th, 26th, 27th, 29th; Nisbet, 1st, 3d, 4th, 5th, 8th, 10th, 12th, 17th, 18th, 21st, 26th; Greenville, 1st, 2d, 3d, 4th, 5th, 8th, 9th, 10th, 12th, 13th, 16th, 17th, 18th, 21st, 24th, 25th, 26th, 27th, 28th, 29th, 30th; Pottstown, 1st, 3d, 10th, 26th, 29th; Philadelphia, 1st, 3d, 8th, 10th, 13th, 26th, 27th, 28th, 29th; Girardville, 1st, 8th, 10th, 16th, 17th, 18th, 26th, 27th, 29th, 31st; Selins Grove, 8th, 17th, 26th, 27th; Somerset, 1st, 2d, 3d, 4th, 8th, 9th, 12th, 17th, 18th, 26th, 27th, 28th, 29th; Wellsboro, 1st, 2d, 3d, 5th, 12th, 17th, 18th, 23d, 26th, 27th, 29th; Lewisburg, 1st, 3d, 5th, 9th, 17th, 26th, 29th; Dyberry, 3d, 4th, 5th, 12th, 17th, 18th, 26th, 29th; Honesdale, 3d, 5th, 9th, 17th, 18th, 26th, 27th, 29th, 31st; Ligonier, 1st, 3d, 17th, 18th, 26th, 27th; South Eaton, 3d, 8th, 11th, 17th, 18th, 26th, 27th, 29th; York, 1st, 3d, 8th, 12th, 17th, 26th, 29th; Smethport, 2d, 3d, 4th, 5th, 12th, 17th, 26th, 27th.

*Sleet.*—Charlesville, 3d; Blue Knob, 27th; Quakertown, 17th, 26th; State College, 31st; Phillipsburg, 6th, 31st; Coatesville, 3d; Lock Haven, 21st, 22d; Petersburg, 3d, 31st; Lancaster, 17th; Nisbet, 18th; Wellsboro, 31st; Dyberry, 3d, 6th, 21st; York, 17th; Selins Grove, 17th, 31st.

*Coronæ.*—Charlesville, 19th, 20th, 24th, 28th; Blue Knob, 15th; Le Roy, 20th, 24th, 31st; Wilkes-Barre, 22d; Dyberry, 20th, 24th, 25th.

*Solar Halos.*—Dyberry, 25th.

*Lunar Halos.*—Charlesville, 24th, 28th; Mauch Chunk, 22d; State College, 19th, 22d; Meadville, 20th, 21st, 22d; Carlisle, 22d; Coopersburg, 20th; Somerset, 19th, 25th, 28th; Dyberry, 25th.

*Meteors.*—Charlesville, 1st, 4th.

*Parhelias.*—Catawissa, 26th; Dyberry, 25th; South Eaton, 30th.

### WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for November, 1890:

Weather, 82 per cent.

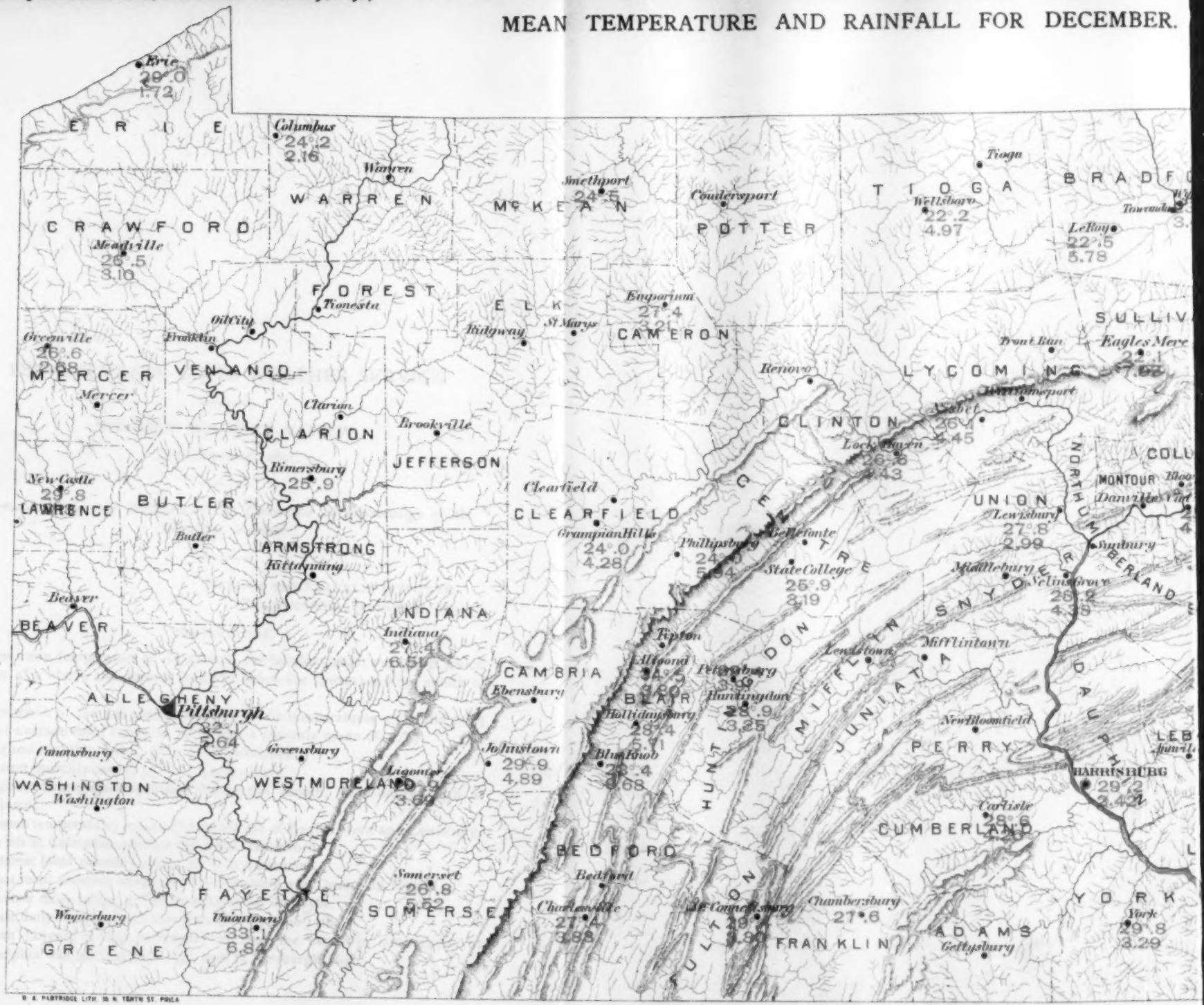
Temperature, 84 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
| Robt. M. Graham, | Catawissa. |
| Henry F. Bitner, | Millersville. |
| A. M. Wildman, | Langhorne. |
| G. W. Klee, | Chambersburg. |
| A. Simon's Sons, | Lock Haven. |
| *Raftsman's Journal*, | Clearfield. |
| R. C. Schmidt & Co., | Belle Vernon. |
| Chas. B. Lutz, | Bloomsburg. |
| E. C. Lorentz, | Johnstown. |
| W. M. James, | Ashland. |
| Miller & Allison, | Punxsutawney. |

| *Displayman.* | *Station.* |
|---|---|
| E. J. Sellers, | Kutztown. |
| C. A. Hinsdell, | Scranton. |
| H. M. Kaisinger, | Hartsville. |
| Foulk & Co., | Milford. |
| William Lawton, | Wilmington, Del. |
| Wister Heberton & Co., | Germantown. |
| Charles M. Mullen, | Bedford. |
| E. W. Merrill, | North East. |
| A. Simon's Sons, | Lock Haven. |
| Frank Ridgway, | Harrisburg. |
| G. W. Yost, | Collegeville. |
| A. C. Tryon, | Spartansburg. |
| A. H. Gerbench, | Annville. |
| Knowles Croskey, | Phoenixville. |
| Powell Bros., | Shadeland. |
| Lincoln E. Rowley, | Athens. |
| P. S. Weber, | Du Bois. |
| E. Jennet, | Franklin. |
| Milton C. Cooper, | Ashbourne. |
| J. L. Long, | Freeport. |
| J. H. Apple, | Clarion. |
| George Wheeler, | Doylestown. |
| J. C. McCloskey, | Lock Haven. |
| Charles Petersen, | Honesdale. |
| Armstrong & Brownell, | Smethport. |

# MEAN TEMPERATURE AND RAINFALL FOR DECEMBER.



# EMPERATURE AND RAINFALL FOR DECEMBER. 1890.

Montrose
SUSQUEHANNA
WAYNE
Honesdale
22.1
4.01
Tunkhannock
South Easton
WYOMING
LACKAWANNA
Scranton
Bloomsburg
Milford
PIKE
Wilkesbarre
LUZERNE
MONROE
Stroudsburg
Drifton
CARBON
Mauch Chunk
27.1
3.48
Girardville
27.5
4.65
NORTHAMPTON
Easton
CHUYLKILL
Pottsville
Lynnport
Bethlehem
LEHIGH
Allentown
Hamburg
Quakertown
27.0
BERKS
BUCKS
Doylestown
Reading
Lebanon
28.2
3.98
2.47
MONTGOMERY
Pottstown
29.7
2.86
Norristown
Phoenixville
CHESTER
Lancaster
Coatesville
West Chester
Swarthmore
Westtown
3.51
DELAWARE
Kennett Square
29.1
3.37

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW.

FOR JANUARY, 1891.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 31, 1891.

### TEMPERATURE.

The mean temperature of 54 stations for January, 1891, was 30°.6, which is over 4°.0 above the normal, and 7°.1 below the corresponding month of 1890.

The mean of the daily maxima and minima temperatures 37°.7 and 23°.3 give an average daily range of 14°.4, and a monthly mean of 30°.5.

Highest monthly mean, 36°.4 at Philadelphia.

Lowest monthly mean, 23°.8 at Eagles Mere.

Highest temperature recorded during the month, 64°.0 on the 29th at Uniontown.

Lowest temperature, minus 4°.0 on the 4th at Eagles Mere and Lewisburg, on the 8th at Columbus, and on the 9th at Wellsboro.

Greatest local monthly range, 20°.2 at Lancaster.

Least local monthly range, 10°.1 at Pittsburg and Grampian Hills.

Greatest daily range, 43° at Smethport on the 25th.

Least daily range, 2° at Grampian Hills, on the 11th.

From January 1, 1891, to January 31, 1891, the excess in temperature at Philadelphia was 122°, at Erie 137°, and at Pittsburgh 164°.

## BAROMETER.

The mean pressure for the month, 30·06, is about ·04 below the normal. At the U. S. Signal Service Stations, the highest observed was 30·67, at Pittsburgh on the 8th, and the lowest, 29·22, at Philadelphia on the 12th.

## PRECIPITATION.

The average precipitation, 3·64 inches for the month, is nearly normal.

The largest totals in inches (including melted snow) were Girardville, 8·74; Coopersburg, 7·29 and Pottstown, 7·00.

The least were Greenville, 1·22; Chambersburg, 2·27; Altoona, 2 35; and Erie, 2·43.

The snowfall average for the State was about 9·00 inches.

The largest totals in inches were Somerset, 40·5; Blue Knob, 33·5; Dyberry, 20·0; Eagles Mere, 19·0; and Charlesville, 15·0.

Only elevated districts report snow on the ground at the end of the month.

## WIND AND WEATHER.

The prevailing wind was from the Northwest. The wind and snow storm of the 25th caused great damage to telegraph and telephone wires.

Average number: Rainy days, 12; clear days, 6; fair days, 10; cloudy days, 15.

NOTE.—Any one having extra copies of the Monthly Weather Review for the months of May and August, 1889, will confer a favor by returning them to the Philadelphia office.

## MISCELLANEOUS PHENOMENA.

*Thunder-storms.*—Charlesville, 29th; Blue Knob, 29th; Quakertown, 11th; Johnstown, 29th; Emporium, 29th; Mauch Chunk, 11th; State College, 29th; Coatesville, 11th; Phœnixville, 11th; Rimersburg, 29th; Grampian Hills, 29th; Lock Haven, 29th; Meadville, 29th; Carlisle, 29th; Swarthmore, 11th; Uniontown, 29th; McConnellsburg, 29th; Indiana, 28th; Lancaster, 11th; Coopersburg, 11th; Nisbet, 29th; Smethport, 30th; Somerset, 19th; Wellsboro, 29th; Columbus, 29th; Dyberry, 12th; Philadelphia, 11th; York, 12th; Hollidaysburg, 29th.

*Hail.*—Phœnixville, 17th, 31st; Meadville, 29th; Smethport, 30th; Somerset, 19th; Wellsboro, 1st, 2d; Dyberry, 17th; Philadelphia, 31st; York, 31st.

*Snow.*—Charlesville, 3d, 5th, 10th, 12th, 17th, 18th, 22d, 24th, 25th, 31st; Blue Knob, 2d, 3d, 4th, 5th, 6th, 7th, 9th, 19th, 12th, 13th, 14th, 17th, 18th, 22d, 23d, 24th, 25th, 26th; Wysox, 11th, 17th, 24th; Le Roy, 3d, 12th, 17th, 18th; Quakertown, 1st, 4th, 7th, 17th, 25th; Johnstown, 2d, 3d, 4th, 5th, 6th, 12th, 17th, 18th, 22d, 23d, 24th, 25th; Emporium, 12th, 13th, 14th, 22d, 23d, 26th, 27th; Mauch Chunk, 17th; State College, 4th, 6th, 12th, 13th, 17th, 18th, 24th, 25th; West Chester, 17th, 24th, 25th; Coatesville, 17th, 24th, 25th

# Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service

| County. | Station. | Elevation above Sea Level (feet). | Barometer Reduced to Sea Level. | | | Temperature. | | | | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maximum. | | Minimum | | | | Daily Range. | | | | | | | | | |
| | | | Mean. | Highest. | Lowest. | Mean. | Highest. | Date. | Lowest. | Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at End of Month. |
| Allegheny,[1] | Pittsburgh, | 847 | 30·090 | 30·670 | 29·270 | 35·0 | 57 | 29 | 18 | 8 | 40·0 | 29·9 | 10·1 | 21·0 | 9 | 4·0 | 22 | 82·2 | 30·0 | 2·43 | 3·20 | . . . |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 28·9 | 53 | 30 | 0 | 4 | 37·3 | 19·6 | 17·7 | 30·0 | 8 | 5·0 | 11 | 81·0 | 23·7 | 2 63 | 15·00 | 2·00 |
| Blair,[2] | Altoona, | 1,181 | . . . | . . . | . . . | 35·5 | 54 | 28 | 13 | 4 | 42·5 | 28·5 | 14·0 | 25 0 | 4 | 8·0 | 20 | 74·4 | 28·5 | 2·35 | . . . | . . . |
| Blair, | Blue Knob, | 2,500 | . . . | . . . | . . . | 25·8 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 3·60 | 33·50 | 36·00 |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 31·0 | 52 | 30 | 3 | 9 | 37·5 | 22·3 | 15·2 | 28 0 | 9 | 6·0 | 31 | 78·6 | 24·7 | 3·74 | 9·00 | . . . |
| Bradford, | Wysox, | 718 | 30·095 | 30·639 | 29·272 | 28·3 | 47 | 2 | 6 | 10 | 33·8 | 19·3 | 14·5 | 27·0 | 26 | 4·5 | 18 | 80·5 | 23·6 | 3·72 | 12·55 | 6·00 |
| Bradford, | Le Roy, | 1,400 | . . . | . . . | . . . | 26·2 | 47 | 27 | 4 | 4 | 32·0 | 21·5 | 10·5 | 20·0 | 27 | 5·0 | 18 | . . . | . . . | 4·63 | 13·05 | 12·00 |
| Bucks, | Forks of Neshaminy, | . . . | . . . | . . . | . . . | 34·0 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 6·11 | . . . | . . . |
| Bucks, | Quakertown, | 536 | 30·110 | 30·560 | 29·190 | 31·1 | 55 | 21 | 9 | 4 | 40·1 | 21·8 | 18·3 | 30 3 | 26 | 9·6 | 29 | 82·5 | 25·9 | 6·26 | 10·00 | . . . |
| Cambria,[1] | Johnstown, | 1,184 | 30·103 | 30·681 | 29·300 | 31·3 | 51 | 30 | 10 | 9 | 37·3 | 26·3 | 11·0 | 25·0 | 9 | 4·0 | 23 | 88·4 | 27·0 | 3·47 | 4·50 | . . . |
| Cameron, | Emporium, | 1,030 | . . . | . . . | . . . | 30·2 | 51 | 27 | 3 | 9 | 37·0 | 21·0 | 16·0 | 32·0 | 17 | 7·0 | 23 | . . . | . . . | 3·47 | 1·00 | . . . |
| Carbon,[1] | Mauch Chunk (27 days), | 550 | . . . | . . . | . . . | 29·7 | 52 | 22 | 8 | 4 | 38·2 | 21·2 | 17·0 | 28·0 | 26 | 8·0 | 2 | . . . | . . . | 6·90 | 5·50 | . . . |
| Centre, | State College— Agricultural Experiment Station, | 1,191 | 30·033 | 30·599 | 29·204 | 28·9 | 49 | 27, 28 | 1 | 3 | 34·9 | 21·1 | 13·8 | 23·0 | 15 | 6·0 | 25 | 88·5 | 25·6 | 4·11 | 13·80 | 4·00 |
| Chester, | West Chester, | 455 | 30·052 | 30·489 | 29·152 | 33·3 | 53 | 12 | 15 | 4, 6 | 40·2 | 26·9 | 13·3 | 21·0 | 12 | 5·0 | 14 | 75·0 | 26·0 | 6·56 | 5·50 | . . . |
| Chester, | Coatesville, | 380 | . . . | . . . | . . . | 31·9 | 56 | 22 | 14 | 4, 6 | 42·3 | 24·0 | 18·3 | 31·0 | 26 | 9·0 | 29 | . . . | . . . | 6·59 | 5·00 | . . . |
| Chester,[1] | Kennett Square, | 275 | . . . | . . . | . . . | 31·7 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 6·08 | 3·00 | . . . |
| Chester, | Phœnixville, | 183 | 30·086 | 30·544 | 29·219 | 34·4 | 56 | 22, 23 | 16 | 4, 6 | 41·7 | 27·1 | 14·6 | 25·0 | 26 | 6·0 | 18 | 81·0 | 26·7 | 5·19 | 5·51 | . . . |
| Chester, | Westtown (23 days), | 350 | 30·049 | 30·541 | 29·256 | 34·6 | 54 | 22 | 16 | 4, 6 | 40·1 | 27·4 | 12·7 | 20·4 | 26 | 6·1 | 29 | . . . | . . . | 5·74 | 4·00 | . . . |
| Clarion, | Rimersburg, | 1,500 | . . . | . . . | . . . | 28·0 | 49 | 29 | 10 | 4 | 32·3 | 23·9 | 8·4 | 20·0 | 2 | 2·0 | 23 | . . . | . . . | . . . | 4·50 | . . . |
| Clarion, | Clarion— State Normal School, | 1,530 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 27·0 | 46 | 27 | 4 | 8 | 31·7 | 21·6 | 10·1 | 26·0 | 8 | 2·0 | 11 | . . . | . . . | 3·62 | 6·00 | 12·00 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | 29·4 | 44 | 24 | 1 | 4 | 35·2 | 20·1 | 15 1 | 27·0 | 8 | 6·0 | 25 | . . . | . . . | 4·21 | 12·00 | 3·00 |
| Columbia, | Catawissa, | 491 | . . . | . . . | . . . | 30·0 | 50 | 22 | 13 | 6 | 35·5 | 24·8 | 10·7 | 24·0 | 11 | 3·0 | 3 | . . . | . . . | 5·26 | 13·00 | . . . |
| Crawford, | Meadville, | 1,300 | 30·151 | 30·700 | 29 370 | 28·2 | 49 | 29 | 5 | 15 | 34·3 | 21·9 | 12·4 | 31·5 | 15 | 4·5 | 22 | 87·0 | 24·7 | 4·12 | 8·75 | . . . |
| Cumberland, | Carlisle, | 480 | . . . | . . . | . . . | 30·7 | 47 | 27, 30 | 12 | 4 | 37·6 | 24·2 | 13·4 | 26·0 | 27 | 4·0 | 29 | 89·0 | 26·0 | 4·07 | 9·75 | . . . |
| Dauphin,[1] | Harrisburg, | 361 | 30·084 | 30·554 | 29·290 | 32·2 | 53 | 22 | 14 | 4 | 37·7 | 26·8 | 10·9 | 19·0 | 22 | 5 0 | 29 | 79·7 | 26·2 | 4·73 | 6·00 | . . . |
| Delaware, | Swarthmore— Swarthmore College, | 190 | 30·034 | 30·449 | 29·416 | 34·1 | 54 | 22 | 15 | 4 | 42·7 | 27·3 | 15·7 | 27·0 | 3 | 6·3 | 18 | 78 0 | 28·0 | 4·84 | 5·00 | . . . |
| Erie,[1] | Erie, | 681 | 30·033 | 30·610 | 29·240 | 31·0 | 52 | 29 | 14 | 3 | 37·0 | 24·0 | 13·0 | 21·0 | 2 | 4·0 | 11 | 83·0 | 24·0 | 2·32 | . . | . . . |
| Fayette, | Uniontown, | 1,000 | 30·107 | 30·557 | 29·453 | 36·2 | 64 | 29 | 19 | 15 | 41·3 | 29·4 | 11·9 | 30·0 | 11 | 4·0 | 18 | . . . | . . . | 3·41 | 2·00 | . . . |
| Franklin,[1] | Chambersburg— Wilson Female College, | 618 | 30·119 | 30·547 | 29·582 | 30·1 | 45 | 22, 23 | 11 | 9 | 37·7 | 22·5 | 15·2 | 27·0 | 19 | 3·0 | 11 | 90·5 | 27·1 | 2·27 | 5·00 | . . . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 31·6 | 51 | 7 | 5 | 11 | 39·2 | 24·0 | 15·2 | 30·0 | 19 | 4·0 | 13 | 79·5 | 26·0 | 4·53 | 15·00 | . . . |
| Huntingdon,[1] | Huntingdon— The Normal College, | 650 | . . . | . . . | . . . | 29·3 | 50 | 31 | 3 | 4, 9 | 38·6 | 20·1 | 18·5 | 32·0 | 9 | 2·0 | 13 | . . . | . . . | 3·58 | 15·25 | . . . |
| Huntingdon, | Petersburg, | 700 | . . . | . . . | . . . | 30·6 | 56 | 27 | 6 | 4 | 36·6 | 26·5 | 10·1 | 32·0 | 27 | 1·0 | 23 | . . . | . . . | 4·29 | 9·00 | . . . |
| Indiana, | Indiana— State Normal School, | 1,350 | 30·027 | 30·570 | 29·336 | 31·0 | 54 | 27 | 3 | 9 | 36·7 | 23·0 | 13·7 | 37·0 | 9 | 4·0 | 11 | 83·9 | 27·8 | 4·40 | 5·50 | . . . |
| Lancaster, | Lancaster (26 days),— Franklin and Marshall College, | 411 | 30·175 | 30·579 | 29·202 | 33·9 | 56 | 23 | 10 | 6 | 43·5 | 23·2 | 20·3 | 41·5 | 6 | 12·0 | 29 | 74·9 | 26·5 | 3·09 | 3·50 | . . . |
| Lawrence, | New Castle, | 932 | . . . | . . . | . . . | 33·3 | 55 | 29 | 6 | 8 | 38·1 | 24·0 | 14·1 | 28·0 | 27 | 3·0 | 2 | 90·1 | 30·9 | 2·88 | 2·35 | . . . |
| Lebanon, | Myerstown, | 474 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Lehigh, | Coopersburg, | 520 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Luzerne, | Drifton— Drifton Hospital, | 1,655 | . . . | . . . | . . . | 32·1 | 54 | 12, 22 | 12 | 4 | 42·2 | 24·6 | 17·6 | 28·0 | 10 | 8·0 | 29 | . . . | . . . | 7·29 | 7·90 | 1·00 |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . . | . . . | . . . | 31·8 | 54 | 22 | 14 | 4 | 39·6 | 24·1 | 15·5 | 30·0 | 3 | 5 0 | 5 | . . . | . . . | 4·59 | 15·00 | 3·00 |
| Lycoming,[1] | Nisbet, | 550 | . . . | . . . | . . . | 28·9 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·00 | 9·60 | . . . |
| McKean, | Smethport, | 1,500 | . . . | . . . | . . . | 27·2 | 47 | 27 | — 2 | 9 | 35·2 | 18·2 | 17·0 | 43·0 | 15 | 6·0 | 18 | . . . | . . . | . . . | . . . | . . . |
| Mercer,[1] | Greenville— Thiel College, | 1,000 | 30·032 | 30·758 | 29·176 | 30·0 | 49 | 2 | 4 | 8 | 36·7 | 23·4 | 13·3 | 29·0 | 15 | 4·0 | 18 | 95·8 | 27·0 | 1·22 | 8·00 | . . . |
| Mifflin, | Pottstown, | 150 | . . . | . . . | . . . | 33·9 | 50 | 22, 27 | 15 | 4 | 40·5 | 27·3 | 13·2 | 25·0 | 26 | 5·0 | 13 | 77·0 | 27·0 | 7·00 | 4·00 | . . . |
| Northampton, | Bethlehem, | 360 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Philadelphia,[1] | Philadelphia— Signal Office, | 117 | 30·074 | 30·550 | 29·220 | 36·4 | 56 | 22 | 17 | 4 | 43·2 | 29·7 | 13·5 | 20·0 | 10 | 7·0 | 13 | 74·0 | 27·0 | 3·65 | 2·50 | . . . |
| Philadelphia, | Philadelphia, | 65 | 30·052 | 30·560 | 29·210 | 36·2 | 55 | 2, 22 | 16 | 4 | 43·1 | 29·3 | 13·8 | 20·0 | 3 | 7·0 | 19 | 82·0 | 31·6 | 5·18 | 3·00 | . . . |
| Schuylkill, | Girardville, | 1,900 | 30·033 | 30·488 | 29·429 | 30·4 | 53 | 22 | 10 | 4 | 34·5 | 23 5 | 15·0 | 24·0 | 27 | 6·0 | 13 | . . . | . . | 8 74 | 22·00 | . . . |
| Snyder, | Selins Grove, | 445 | . . . | . . | . . . | 30·1 | 50 | 31 | . . . | . . . | 38·0 | 22·2 | 15·8 | . . . | . . . | . . . | . . . | . . . | . . . | 8·59 | 13·00 | . . . |
| Somerset, | Somerset, | 2,250 | . . . | . . . | . . . | 29·0 | 54 | 2 | — 1 | 8 | 35·3 | 20·3 | 15·0 | 28·0 | 15 | 4·0 | 18 | 90·2 | 27·1 | 5·51 | 40·50 | 6·00 |
| Sullivan, | Eagles Mere, | 2,060 | 30·144 | 30·589 | 29·491 | 23·8 | 44 | 22 | — 4 | 3, 4 | 30·2 | 18·6 | 11·6 | 28·0 | 3 | 6·0 | 29 | 75 8 | 17·8 | 5·60 | 19·00 | 24·00 |
| Tioga, | Wellsboro, | 1,327 | 30·046 | 30·652 | 29·283 | 25·2 | 48 | 27 | — 4 | 9 | 33·4 | 18·9 | 14·5 | 30·0 | 15 | 4·0 | 29 | 78·3 | 23·6 | 6·53 | 5·00 | 14·00 |
| Union,[1] | Lewisburg, | 430 | . . . | . . . | . . . | 29·9 | 47 | 27 | 7 | 4 | 38·1 | 21·8 | 16·3 | 25·0 | 27 | 8·0 | 31 | . . . | . . . | 3·31 | 12·00 | 1·00 |
| Warren, | Columbus, | 1,410 | . . . | . . . | . . . | 26·7 | 47 | 29 | — 4 | 8 | 33·8 | 19·5 | 14·3 | 38·0 | 9 | 1·0 | 30 | 72·0 | 18·0 | 2·57 | . . . | . . . |
| Washington, | Canonsburg, | 950 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Wayne, | Dyberry, | 1,100 | . . . | . . . | . . . | 24·9 | 47 | 2 | — 2 | 4, 10 | 33·2 | 15·7 | 17·5 | 33·0 | 10 | 4·0 | 29 | . . . | . . . | 5·30 | 17·00 | 20·00 |
| Wayne, | Honesdale, | 1,100 | . . . | . . . | . . . | 26·4 | 49 | 2 | 0 | 26 | 34·7 | 18·0 | 16·7 | 40·0 | 26 | 5·0 | 13 | . . . | . . . | 4·21 | 20·00 | 6·00 |
| Westmoreland, | Ligonier (28 days), | 1,750 | . . . | . . . | . . . | 30·9 | 58 | 28 | 7 | 9 | 37·7 | 22·6 | 15·1 | 32·0 | 9 | 5 0 | 18 | . . . | . . . | 3·39 | 3·60 | . . . |
| Wyoming,[1] | South Eaton | 660 | . . . | . . . | . . . | 28·9 | 47 | 2, 22 | 8 | 4 | 35·8 | 22·0 | 13·8 | 25·0 | 10 | 6·0 | 19 | . . . | . . . | 5·47 | 11·00 | 10·00 |
| York,[1] | York, | 385 | . . . | . . . | . . . | 32·0 | 54 | 22 | . . . | . . . | 41·0 | 23·0 | 18·0 | . . . | . . . | . . . | . . . | 84·5 | 27·1 | 3·05 | 7·75 | . . . |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

# TS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE

| TEMPERATURE. | | | | | | | | | Relative Humidity. | Dew Point. | PRECIPITATIO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINIMUM | | Mean of Maximum. | Mean of Minimum. | DAILY RANGE. | | | | | | | | | |
| Lowest. | Date. | | | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at |
| 18 | 8 | 40·0 | 29·9 | 10·1 | 21·0 | 9 | 4·0 | 22 | 82·2 | 30·0 | 2·43 | 3·20 | . . |
| 0 | 4 | 37·3 | 19·6 | 17·7 | 30·0 | 8 | 5·0 | 11 | 81·0 | 23·7 | 2·63 | 15·00 | 2·0 |
| 13 | 4 | 42·5 | 28·5 | 14·0 | 25·0 | 4 | 8·0 | 20 | 74·4 | 28·5 | 2·35 | . . | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 3·60 | 33·50 | 36·0 |
| 3 | 9 | 37·5 | 22·3 | 15·2 | 28·0 | 9 | 6·0 | 31 | 78·6 | 24·7 | 3·74 | 9·00 | . . |
| 6 | 10 | 33·8 | 19·3 | 14·5 | 27·0 | 26 | 4·3 | 18 | 80·5 | 23·6 | 3·72 | 12·35 | 6·0 |
| 4 | 4 | 32·0 | 21·5 | 10·5 | 20·0 | 27 | 5·0 | 18 | . . . | . . . | 4·63 | 13·05 | 12·0 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 0·11 | . . . | . . |
| 9 | 4 | 40·1 | 21·8 | 18·3 | 30·3 | 26 | 9·8 | 29 | 82·5 | 25·9 | 6·26 | 10·00 | . . |
| 10 | 9 | 37·3 | 26·3 | 11·0 | 25·0 | 9 | 4·0 | 23 | 88·4 | 27·0 | 3·47 | 4·50 | . . |
| 3 | 9 | 37·0 | 21·0 | 16·0 | 32·0 | 17 | 7·0 | 23 | . . . | . . . | 3·47 | 1·00 | . . |
| 8 | 4 | 38·2 | 21·2 | 17·0 | 28·0 | 26 | 8·0 | 2 | . . . | . . . | 6·90 | 5·50 | . . |
| 1 | 3 | 34·9 | 21·1 | 13·8 | 23·0 | 15 | 6·0 | 25 | 88·5 | 25·6 | 4·11 | 13·80 | 4·0 |
| 15 | 4, 6 | 40·2 | 26·9 | 13·3 | 21·0 | 12 | 5·0 | 14 | 75·0 | 26·0 | 6·56 | 5·50 | . . |
| 14 | 4, 6 | 42·3 | 24·0 | 18·3 | 31·0 | 26 | 9·0 | 29 | . . . | . . . | 6·59 | 5·00 | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 6·08 | 3·00 | . . |
| 16 | 4, 6 | 41·7 | 27·1 | 14·6 | 23·0 | 26 | 6·0 | 18 | 81·6 | 26·7 | 5·19 | 5·51 | . . |
| 16 | 4, 6 | 40·1 | 27·4 | 12·7 | 20·4 | 26 | 6·1 | 29 | . . . | . . . | 5·74 | 4·00 | . . |
| 10 | 4 | 32·3 | 23·9 | 8·4 | 20·0 | 2 | 2·0 | 23 | . . . | . . . | . . . | 4·50 | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 4 | 8 | 31·7 | 21·6 | 10·1 | 26·0 | 8 | 2·0 | 11 | . . . | . . . | 3·64 | 6·00 | 12·0 |
| 1 | 4 | 33·2 | 20·1 | 15·1 | 27·0 | 8 | 6·0 | 25 | . . . | . . . | 4·21 | 12·00 | 3·0 |
| 25 | 6 | 35·5 | 24·8 | 10·7 | 24·0 | 11 | 3·0 | 3 | . . . | . . | 5·26 | 13·00 | . . |
| 5 | 15 | 34·3 | 21·9 | 12·4 | 31·5 | 15 | 4·5 | 22 | 87·0 | 24·7 | 4·12 | 8·75 | . . |
| 12 | 4 | 37·6 | 24·2 | 13·4 | 26·0 | 27 | 4·0 | 29 | 89·0 | 26·0 | 4·07 | 9·75 | . . |
| 14 | 4 | 37·7 | 26·8 | 10·9 | 19·0 | 22 | 5·0 | 29 | 79·7 | 26·2 | 4·73 | 6·00 | . |
| 15 | 4 | 42·7 | 27·3 | 15·7 | 27·0 | 3 | 6·3 | 18 | 78·0 | 28·0 | 4·64 | 5·00 | . . |
| 14 | 3 | 37·0 | 24·0 | 13·0 | 21·0 | 2 | 4·0 | 11 | 83·0 | 24·0 | 2·32 | . . | . . |
| 19 | 15 | 41·3 | 29·4 | 11·9 | 30·0 | 11 | 4·0 | 18 | . . . | . . . | 3·41 | 2·00 | . . |
| 11 | 9 | 37·7 | 22·5 | 15·2 | 27·0 | 19 | 3·0 | 11 | 90·5 | 27·1 | 2·27 | 5·00 | . . |
| 5 | 11 | 39·2 | 24·0 | 15·2 | 30·0 | 19 | 4·0 | 13 | 79·5 | 26·0 | 4·53 | 15·00 | . . |
| 3 | 4, 9 | 38·6 | 20·1 | 18·5 | 32·0 | 9 | 2·0 | 13 | . . . | . . . | 3·58 | 15·25 | . . |
| 6 | 4 | 36·6 | 26·5 | 10·1 | 32·0 | 27 | 1·0 | 23 | . . . | . . . | 4·29 | 9·00 | . . |
| 3 | 9 | 36·7 | 23·0 | 13·7 | 37·0 | 9 | 4·0 | 11 | 83·9 | 27·8 | 4·40 | 5·50 | . |
| 10 | 6 | 43·5 | 23·2 | 20·3 | 41·5 | 6 | 12·0 | 29 | 74·9 | 26·5 | 3·09 | 3·50 | . . |
| 6 | 8 | 38·1 | 24·0 | 14·1 | 28·0 | 27 | 3·0 | 2 | 90·1 | 30·9 | 2·88 | 2·35 | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 12 | 4 | 42·2 | 24·6 | 17·6 | 28·0 | 10 | 8·0 | 29 | . . . | . . . | 7·29 | 7·90 | 1·0 |
| . . . | . . . | . . . | . . . | . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 14 | 4 | 39·6 | 24·1 | 15·5 | 30·0 | 3 | 5·0 | 3 | . . . | . . . | 4·59 | 15·00 | 3·0 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·00 | 9·60 | . . |
| — 2 | 9 | 35·2 | 18·2 | 17·0 | 43·0 | 15 | 6·0 | 18 | . . . | . . . | . . . | . . . | . . |
| 4 | 8 | 36·7 | 23·4 | 13·3 | 29·0 | 15 | 4·0 | 18 | 95·8 | 27·0 | 1·92 | 8·00 | . . |
| 15 | 4 | 40·5 | 27·3 | 13·2 | 25·0 | 26 | 5·0 | 13 | 77·0 | 27·0 | 7·00 | 4·00 | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 17 | 4 | 43·2 | 29·7 | 13·5 | 20·0 | 10 | 7·0 | 13 | 74·0 | 27·0 | 3·65 | 2·50 | . . |
| 16 | 4 | 43·1 | 29·3 | 13·8 | 20·0 | 3 | 7·0 | 19 | 82·0 | 31·6 | 5·18 | 3·00 | . . |
| 10 | 4 | 34·5 | 23·5 | 15·0 | 24·0 | 27 | 6·0 | 13 | . . . | . . . | 8·74 | 22·00 | . . |
| . . . | . . . | 38·0 | 22·2 | 15·8 | . . . | . . . | . . . | . . . | . . . | . . . | 8·59 | 13·00 | . . |
| — 1 | 8 | 35·3 | 20·3 | 15·0 | 28·0 | 15 | 4·0 | 18 | 90·2 | 27·1 | 5·51 | 40·50 | 6·0 |
| — 4 | 3, 4 | 30·2 | 18·6 | 11·6 | 28·0 | 3 | 6·0 | 29 | 75·8 | 17·8 | 5·50 | 19·00 | 24·0 |
| — 4 | 9 | 33·4 | 18·9 | 14·5 | 30·0 | 15 | 4·0 | 29 | 78·3 | 23·6 | 6·53 | 5·00 | 14·0 |
| 7 | 4 | 38·1 | 21·8 | 16·3 | 25·0 | 27 | 8·0 | 31 | . . . | . . . | 3·33 | 12·00 | 1·0 |
| — 4 | 8 | 33·8 | 19·5 | 14·3 | 38·0 | 9 | 1·0 | 30 | 72·0 | 18·0 | 2·57 | . . . | . . |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| — 2 | 4, 10 | 33·2 | 15·7 | 17·5 | 39·0 | 10 | 4·0 | 29 | . . . | . . . | 5·30 | 17·00 | 20·0 |
| 0 | 26 | 34·7 | 18·0 | 16·7 | 40·0 | 26 | 5·0 | 13 | . . . | . . . | 4·21 | 20·00 | 6·0 |
| 7 | 9 | 37·7 | 22·6 | 15·1 | 32·0 | 9 | 5·0 | 18 | . . . | . . . | 3·39 | 3·60 | . . |
| 8 | 4 | 35·8 | 22·0 | 13·8 | 25·0 | 10 | 6·0 | 19 | . . . | . . . | 5·47 | 11·00 | 10·0 |
| . . . | . . . | 41·0 | 23·0 | 18·0 | . . . | . . . | . | . . . | 84·5 | 27·1 | 3·05 | 7·75 | . . |

| Precipitation. | | | Number of Days. | | | Wind. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Prevailing Direction. | | | |
| Total Snowfall During Month. | Depth of Snow on Ground at End of Month. | Number of Days Rainfall. | Clear. | Fair. | Cloudy. | 7 A. M. | 2 P. M. | 9 P. M. | Observers. |
| 3·80 | . . . | 17 | 2 | 5 | 24 | W | W | W | Oscar D. Stewart, Sgt. Sig. Corps. |
| 15·00 | 2·00 | 9 | 3 | 9 | 18 | SW | SW | SW | Miss E. A. G. Apple. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| 33·50 | 36·00 | 20 | 2 | 10 | 19 | NW | NW | NW | A. H. Boyle. |
| 9·00 | . . | 16 | 7 | 10 | 14 | W | W | W | Prof. J. A. Stewart. |
| 12·55 | 6·00 | 9 | 5 | 6 | 20 | SW | NW | W | Charles Beecher. |
| 13·05 | 12·00 | 11 | 4 | 10 | 17 | SW | SW | SW | Geo. W. T. Warburton |
| . . . | . . . | 11 | 9 | 16 | 6 | N | N | W | J. C. Hilsman. |
| 10·00 | . . . | 11 | 5 | 15 | 11 | NW | NW | NW | J. L. Heacock. |
| 4·50 | . . . | 21 | 2 | 10 | 19 | S | S | S | E. C. Lorentz. |
| 1·00 | . . . | 9 | 4 | 8 | 19 | NW | NW | W | T. B. Lloyd. |
| 5·50 | . . . | 7 | 7 | 14 | 6 | NW | NW | NW | John J. Boyd. |
| 13·80 | 4·00 | 14 | 4 | 6 | 21 | W | W | W | Prof. Wm. Frear. |
| 5·50 | . . . | 12 | 14 | 5 | 12 | NW | NW | NW | Jesse C. Green, D.D.S. |
| 5·00 | . . . | 11 | 6 | 14 | 11 | W | W | W | W. T. Gordon. |
| 3·00 | . . . | 10 | 9 | 13 | 9 | NW | NW | NW | Benj. P. Kirk. |
| 5·51 | . . . | 12 | 7 | 7 | 17 | NW | NW | NW | Knowles Croskey. |
| 4·00 | . . . | 6 | 6 | 9 | 8 | W | W | NW | Prof. Wm. F. Wickersham. |
| 4·50 | . . . | 19 | 4 | 4 | 23 | W | W | W | Rev. W. W. Deatrick, A.M. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | C. M. Thomas, B.S. |
| 6·00 | 12·00 | 11 | 4 | 7 | 20 | W | W | W | Nathan Moore. |
| 12·00 | 3·00 | 11 | 5 | 6 | 20 | W | W | W | Prof. John A. Robb. |
| 13·00 | . . . | 11 | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| 8·75 | . . . | 14 | 1 | 7 | 23 | SW | NW | W | J. & B. H. Metcalf. |
| 9·75 | . . . | 11 | 4 | 17 | 10 | NW | W | W | J. E. Pague. |
| 6·00 | . . . | 13 | 5 | 15 | 11 | W | W | W | Frank Ridgway, Sgt. Sig. Corps. |
| 5·00 | . . . | 9 | . . . | 16 | 15 | SW | NW | NW | Prof. Susan J. Cunningham. |
| . . | . . . | 18 | 1 | 7 | 23 | SW | SW | SW | Peter Wood, Sgt. Sig. Corps. |
| 2·00 | . . . | 9 | 5 | 11 | 15 | SW | W | SW | Wm. Hunt. |
| 5·00 | . . . | 6 | . . . | . . . | . . . | . . . | . . . | . . . | Miss Mary A. Ricker. |
| 15·00 | . . . | 8 | 9 | 13 | 7 | W | W | W | Thomas F. Sloan. |
| 15·25 | . . . | 6 | 5 | 12 | 14 | W | W | W | Prof. W. J. Swigart. |
| 9·00 | . . . | 10 | 5 | 12 | 14 | W | W | N | J. E. Rooney. |
| 5·50 | . . | 13 | 2 | 4 | 25 | NW | SW | NW | Prof. S C. Schmucker. |
| 3·50 | . . . | 6 | 5 | 14 | 7 | NW | NW | NW | Lewis T. Lampe. |
| 2·35 | . . . | 9 | 3 | 8 | 20 | SE | SE | NW | Wm. T. Butz. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Wm. H. Kline. |
| 7·90 | 1·00 | 12 | 10 | 10 | 11 | NW | SW | NW | M. H. Boye. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| 15·00 | 3·00 | 9 | 14 | . . . | 17 | N | . . . | NE | A. W Betterly. |
| 9·60 | . . . | 12 | . . . | . | . . . | W | W | W | John S. Gibson, P. M. |
| . . . | . . . | . . . | . . . | . . . | . . . | SW | S | W | Armstrong & Brownell. |
| 8·00 | . . . | 14 | 1 | 4 | 26 | N | N | N | Prof. S. H. Miller. |
| 4·00 | . . . | 8 | 13 | 12 | 6 | W | W | W | Charles Moore, D.D.S. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Lerch & Rice. |
| 2·50 | . . . | 10 | 8 | 8 | 15 | NW | NW | NW | Luther M. Dey, Sgt. Sig. Corps. |
| 3·00 | . . . | 10 | 6 | 13 | 12 | NW | NW | NW | John Comly. |
| 22·00 | . . . | 13 | 8 | 14 | 9 | W | W | NW | E. C. Wagner. |
| 13·00 | . . . | 9 | 3 | 24 | 4 | NW | SW | SW | J. M. Boyer, |
| 40·50 | 6·00 | 18 | 4 | 2 | 25 | NW | NW | NW | W. M. Schrock. |
| 19·00 | 24·00 | 12 | 4 | 11 | 16 | SW | SW | SW | E. S. Chase. |
| 5·00 | 14·00 | 10 | 2 | 9 | 20 | N | SW | S | H. D. Deming. |
| 12·00 | 1·00 | 10 | 8 | 15 | 8 | NE | NE | NE | F. O. Whitman. |
| . . . | . . . | 15 | 1 | 7 | 23 | SW | SW | SW | Wm. Loveland. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | A. L. Runion, M.D. |
| 17·00 | 20·00 | 14 | 3 | 12 | 16 | NW | W | NW | Theodore Day. |
| 20·00 | 6·00 | 14 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| 3·60 | . . . | 8 | 4 | 6 | 18 | . . . | . . . | . . . | J. T. Ambrose. |
| 11·00 | 10·00 | 11 | 7 | 10 | 14 | S | S | S | Benj. M. Hall. |
| 7·75 | . . . | 11 | 17 | 4 | 10 | NW | NW | NW | Mrs. L. H. Grenewald. |

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

Phœnixville, 1st, 5th, 7th, 17th, 25th; Westtown, 25th; Rimersburg, 2d, 3d, 4th, 5th, 6th, 12th, 13th, 14th, 17th, 22d, 26th; Grampian Hills, 4th, 5th, 12th, 13th, 17th, 22d; Lock Haven, 17th, 18th, 24th, 25th; Catawissa, 17th, 18th, 25th; Meadville, 3d, 5th, 6th, 12th, 14th, 22d, 23d, 26th; Carlisle, 17th, 18th, 25th; Swarthmore, 25th; Uniontown, 2d, 4th, 5th, 6th, 7th, 12th, 13th, 14th, 23d; Huntingdon, 17th, 18th, 24th; Petersburg, 17th, 18th, 25th; Indiana, 2d, 4th, 5th, 6th, 7th, 10th, 12th, 24th, 25th, 30th; Lancaster, 6th, 17th, 18th; New Castle, 3d, 6th, 12th, 13th, 22d; Coopersburg, 1st, 17th, 18th, 25th; Wilkes-Barre, 1st, 18th, 25th; Nisbet, 17th, 18th, 25th, 27th; Smethport, 2d, 3d, 4th, 5th, 6th, 10th, 12th, 13th, 14th, 22d, 26th, 30th; Greenville, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 11th, 12th, 13th, 14th, 17th, 18th, 22d, 23d, 26th, 30th; Pottstown, 17th, 25th; Philadelphia, 5th, 18th, 25th; Girardville, 5th, 12th, 18th, 24th, 25th; Somerset, 1st, 3d, 5th, 6th, 7th, 12th, 13th, 17th, 18th, 25th; Eagles Mere, 3d, 5th, 7th, 12th, 14th, 17th, 18th, 23d, 25th; Wellsboro, 13th, 18th; Lewisburg, 14th, 17th, 18th, 25th; Dyberry, 1st, 2d, 3d, 4th, 5th, 6th, 12th, 13th, 14th, 17th, 18th, 23d, 25th, 26th, 28th, 29th, 30th, 31st; South Eaton, 14th, 17th, 18th, 25th; York, 17th, 25th; Hollidaysburg, 4th, 12th, 17th, 18th, 24th; Altoona, 17th, 18th, 22d, 25th; Kennett Square, 25th.

*Sleet.*—Charlesville, 31st; West Chester, 17th; Coatesville, 17th; Rimersburg, 19th; Lock Haven, 22d; Lancaster, 17th; Wellsboro, 1st, 2d; Dyberry, 1st, 11th, 17th, 31st; South Eaton, 17th; Philadelphia, 17th; York, 17th.

*Coronæ.*—Charlesville, 15th, 20th, 22d; Le Roy, 20th; Rimersburg, 15th, 16th, 22d, 24th, 28th; Greenville, 24th; Dyberry, 15th, 20th, 21st, 31st.

*Solar Halos.*—Le Roy, 4th, 13th; Eagles Mere, 9th, 13th; Dyberry, 28th; Philadelphia, 9th, 15th.

*Lunar Halos.*—Le Roy, 15th, 20th; State College, 15th, 18th; West Chester, 20th; Phœnixville, 15th; Meadville, 16th, 25th; Carlisle, 15th, 21st, 25th, 28th, 29th; Lancaster, 25th, 27th; Nisbet, 20th; Greenville, 15th; Eagles Mere, 15th, 20th; Wellsboro, 15th, 21st, 24th; Dyberry, 15th, 20th, 21st; South Eaton, 20th; Philadelphia, 15th, 20th.

*Meteors.*—State College, 3d; Coopersburg, 7th.

*Parhelias.*—Wellsboro, 15th; Philadelphia, 23d.

*Zodiacal Lights.*—Charlesville, 29th; Dyberry, 9th.

### WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for January, 1891:

Weather, 80 per cent.

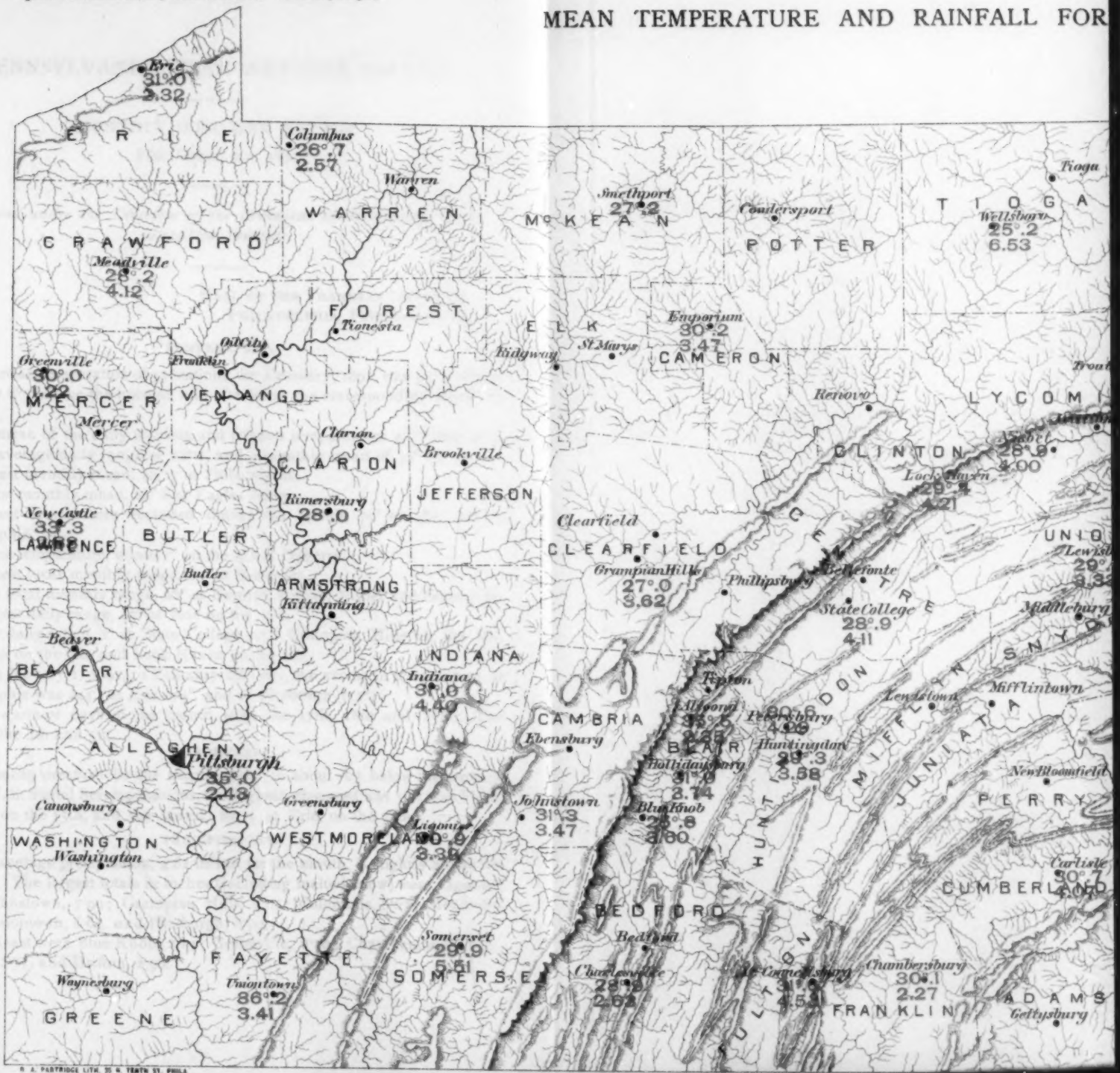
Temperature, 86 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
| Robt. M. Graham, | Catawissa. |
| Henry F. Bitner, | Millersville. |
| A. M. Wildman, | Langhorne. |
| G. W. Klee, | Chambersburg. |
| A. Simon's Sons, | Lock Haven. |
| *Raftsman's Journal*, | Clearfield. |
| R. C. Schmidt & Co., | Belle Vernon. |
| Chas. B. Lutz, | Bloomsburg. |
| E. C. Lorentz, | Johnstown. |
| W. M. James, | Ashland. |
| Miller & Allison, | Punxsutawney. |

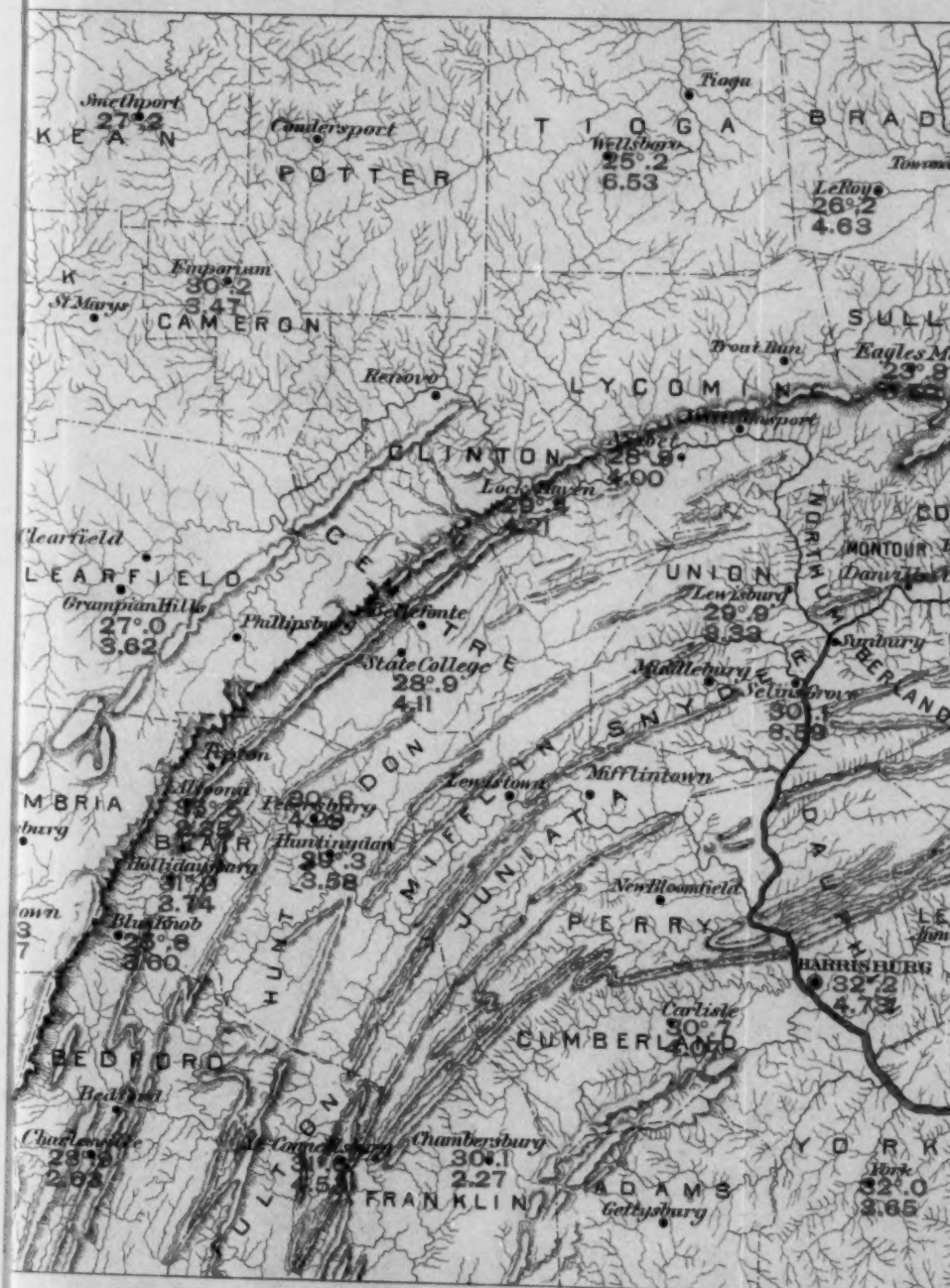
| *Displayman.* | *Station.* |
|---|---|
| E. J. Sellers, | Kutztown. |
| H. M. Kaisinger, | Hartsville. |
| Foulk & Co., | Milford. |
| William Lawton, | Wilmington, Del. |
| Wister Heberton & Co., | Germantown. |
| Charles M. Mullen, | Bedford. |
| E. W. Merrill, | North East. |
| A. Simon's Sons, | Lock Haven. |
| Frank Ridgway, | Harrisburg. |
| G. W. Yost, | Collegeville. |
| A. H. Gerbench, | Annville. |
| Knowles Croskey, | Phoenixville. |
| Powell Bros., | Shadeland. |
| Lincoln E. Rowley, | Athens. |
| P. S. Weber, | Du Bois. |
| E. Jennet, | Franklin. |
| Milton C. Cooper, | Ashbourne. |
| J. L. Long, | Freeport. |
| J. H. Apple, | Clarion. |
| George Wheeler, | Doylestown. |
| J. C. McCloskey, | Lock Haven. |
| Charles Petersen, | Honesdale. |
| Armstrong & Brownell, | Smethport. |

# MEAN TEMPERATURE AND RAINFALL FOR




H. A. PERTRIDGE LITH. 35 N. TENTH ST. PHILA.

# IEAN TEMPERATURE AND RAINFALL FOR JANUARY



*State Weather Service.*

NUARY. 1891.

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW.

FOR FEBRUARY, 1891.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 28, 1891.

### TEMPERATURE.

The mean temperature of 55 stations for February, 1891, was 34°.9, which is nearly 6°.0 above the normal, and 2°.2 below the corresponding month of 1890.

The mean of the daily maxima and minima temperatures 42°.8 and 26°.7 give an average daily range of 16°.1, and a monthly mean of 34°.7.

Highest monthly mean, 40°.5 at Philadelphia.

Lowest monthly mean, 26°.8 at Eagles Mere.

Highest temperature recorded during the month, 70° on the 18th at Philadelphia.

Lowest temperature, minus 7° on the 5th at Dyberry.

Greatest local monthly range, 63° at Somerset.

Least local monthly range, 46° at Kennett Square, Nisbet and Greenville.

Greatest daily range, 43° at Erie on the 5th.

Least daily range, 2° at State College and Grampian Hills on the 8th, Pottstown on the 7th, and Lock Haven on the 4th.

From January 1, 1891, to February 28, 1891, the excess in temperature at Philadelphia was 244°, at Erie 274°, and at Pittsburgh 313°.

The warmest days of the month were the 17th, 18th and 25th. The coldest, the 4th and 5th.

### BAROMETER.

The mean pressure for the month, 30.07, is about .03 below the normal. At the U. S. Signal Service Stations, the highest observed was 30.71, at Philadelphia, on the 15th, and the lowest, 29.25, at Erie, on the 25th.

### PRECIPITATION.

The average precipitation, 4.61 inches for the month, is slightly above the normal. The largest totals in inches (including melted snow) were Ligonier, 8.29; Johnstown, 7.99; Grampian Hills, 7.01; Columbus, 6.67; Meadville, 6.65; Uniontown, 6.64, and Pittsburgh, 6.09.

The least were Blue Knob, 2.13; Greenville, 2.50; Chambersburg, 2.54; Wysox, 2.71, and Drifton, 2.90.

The snowfall was light outside of the more elevated sections. Dyberry reports 17·5 inches; Blue Knob, 16·0; Nisbet, 15·0; Grampian Hills, 13·5; Eagles Mere, 12·5; and Le Roy, 12·3. Several stations report snow on the ground at the end of the month. Heavy rains occurred on the 16th and 17th, which caused heavy freshets in many parts of the state.

### WIND AND WEATHER.

The prevailing wind was from the Northwest.

Average number: Rainy days, 12; clear days, 6; fair days, 8; cloudy days, 14.

CORRECTION.—For January. Greatest monthly range, 55·0 at Somerset. Least local monthly range 34·0 at Chambersburg.

### MISCELLANEOUS PHENOMENA.

*Thunder-storms.*—Charlesville, 25th; Blue Knob, 25th; Johnstown, 25th; Westtown, 28th; Meadville, 25th; Uniontown, 17th; Greenville, 9th; Columbus, 25th; York, 1st.

*Hail.*—Quakertown, 26th; Phœnixville, 6th, 12th, 20th; Indiana, 1st; Lancaster, 12th, 19th, 20th; Wilkes-Barre, 9th; Nisbet, 9th, 18th, 20th; Columbus, 25th; Dyberry, 9th, 20th; York, 13th.

*Snow.*—Charlesville, 10th, 19th, 20th, 26th, 27th, 28th; Blue Knob, 3d, 7th, 10th, 11th, 20th, 21st, 22d, 26th, 27th, 28th; Hollidaysburg, 7th, 10th, 26th, 27th, 28th; Wysox, 7th, 19th, 20th, 28th; Le Roy, 4th, 7th, 9th, 20th, 27th, 28th; Quakertown, 6th, 7th, 26th, 27th; Johnstown, 10th, 22d, 27th, 28th; Emporium, 7th, 20th, 28th; State College, 4th, 7th, 9th, 10th, 20th, 28th; Coatesville, 26th; Kennett Square, 26th; Phœnixville, 26th, 27th; Rimersburg, 4th, 10th, 22d, 26th, 28th; Grampian Hills, 7th, 28th; Lock Haven, 9th, 20th, 28th; Meadville, 3d, 4th, 20th, 22d, 26th, 27th, 28th; Carlisle, 26th, 28th; Uniontown, 10th, 19th, 26th, 28th; Chambersburg, 26th; Huntingdon, 20th, 28th; Indiana, 10th, 26th, 27th, 28th; Lancaster, 26th, 28th; New Castle, 26th, 27th, 28th; Lebanon, 20th, 26th, 28th; Coopersburg, 20th, 26th; Wilkes-Barre, 9th, 20th, 26th, 28th; Nisbet, 1st, 7th, 9th, 20th, 28th; Smethport, 7th, 10th, 20th, 28th; Greenville, 3d, 4th, 7th, 8th, 10th, 18th, 20th, 21st, 22d, 26th, 27th, 28th; Pottstown, 26th; Philadelphia, 20th, 26th, 27th; Girardville, 7th, 20th, 26th; Somerset, 10th, 19th, 20th, 27th, 28th; Eagles Mere, 4th, 7th, 10th, 20th, 28th; Wellsboro, 7th, 9th, 20th, 28th; Lewisburg, 7th, 20th, 27th, 28th; Columbus, 1st, 2d, 3d, 4th, 7th, 10th, 14th, 20th, 22d, 26th, 27th, 28th; Dyberry, 7th, 8th, 9th, 20th, 26th, 27th, 28th; Ligonier, 27th, 28th; South Eaton, 8th, 20th, 28th; York, 26th, 28th.

*Sleet.*—Charlesville, 19th, 20th; Blue Knob, 3d; Hollidaysburg, 20th; Le Roy, 9th, 20th; Quakertown, 6th; Johnstown, 19th; Coatesville, 6th, 20th, 21st; Rimersburg, 19th, 20th; Grampian Hills, 20th; Lock Haven, 7th; Carlisle, 9th, 12th, 20th; Lebanon, 20th; Wilkes-Barre, 9th; Nisbet, 7th, 9th, 20th; Smethport, 1st; Philadelphia, 20th, 26th; Somerset, 20th; Dyberry, 9th, 20th, 21st; South Eaton, 9th, 20th; York, 20th.

*Aurora.*—Eagles Mere, 11th.

# Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service

| County. | Station. | Elevation above Sea Level (feet). | Barometer Reduced to Sea Level. | | | Temperature. | | | | | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mean. | Highest. | Lowest. | Mean. | Maximum. | | Minimum. | | Mean of Maximum. | Mean of Minimum. | Daily Range. | | | | | | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at |
| | | | | | | | Highest. | Date. | Lowest. | Date. | | | Mean. | Greatest. | Date. | Least. | Date. | | | | | | |
| Allegheny,[1] | Pittsburgh, | 847 | 30·070 | 30·600 | 29·480 | 39·2 | 68 | 20 | 9 | 4 | 47·2 | 31·3 | 15·9 | 36·0 | 20 | 4·0 | 10 | 79·2 | 32·8 | 6·09 | 2·30 | 2·0 |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 34·7 | 65 | 17 | 9 | 4 | 44·0 | 27·3 | 16·7 | 31·0 | 15 | 7·0 | 10 | 75·0 | 28·1 | 4·10 | 1·25 | . . |
| Blair,[2] | Altoona (26 days), | 1,181 | . . . | . . . | . . . | 40·1 | 64 | 17 | 13 | 5 | 48·6 | 31·6 | 17·0 | 35·0 | 4 | 6·0 | 20 | 73·5 | 32·0 | 4·59 | . . . | . . |
| Blair, | Blue Knob, | 2,500 | . . . | . . | . . . | 29·8 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·13 | 16·00 | 34·0 |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 35·5 | 62 | 17, 25 | 6 | 5 | 43·4 | 26·8 | 16·6 | 31·0 | 6 | 5·0 | 7 | 77·0 | 29·0 | 5·92 | 4·75 | 1·0 |
| Bradford, | Wysox, | 718 | 30·088 | 30·684 | 29·447 | 31·6 | 59 | 25 | 3 | 5 | 38·4 | 23·0 | 15·4 | 33·0 | 15 | 6·5 | 4 | 79·7 | 26·1 | 2·71 | 6·05 | . . |
| Bradford, | Le Roy, | 1,400 | . . . | . . . | . . . | 29·2 | 52 | 25 | 3 | 5 | 35·1 | 23·3 | 11·8 | 24·0 | 15 | 4·0 | 2 | . . . | . . . | 3·13 | 12·30 | 1·0 |
| Bucks, | Forks of Neshaminy, | . . . | . . . | . . . | . . . | 37·8 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·50 | . . . | . . |
| Bucks, | Quakertown, | 536 | 30·110 | 30·650 | 29·510 | 34·6 | 62 | 25 | 1 | 28 | 44·2 | 25·3 | 18·9 | 39·0 | 28 | 5·0 | 7 | 81·0 | 28·5 | 5·13 | 6·00 | 9·0 |
| Cambria,[1] | Johnstown, | 1,184 | 30·118 | 30·635 | 29·438 | 37·4 | 62 | 17, 25 | 11 | 4 | 45·3 | 29·4 | 15·9 | 31·0 | 5 | 8·0 | 7 | 87·6 | 33·0 | 7·99 | . . . | 3·0 |
| Cameron, | Emporium, | 1,030 | . . . | . . . | . . . | 33·8 | 61 | 25 | 4 | 5 | 41·9 | 24·0 | 17·9 | 36·0 | 6 | 9·0 | 10 | . . . | . . . | 4·56 | 6·37 | . . |
| Carbon,[1] | Mauch Chunk (18 days), | 550 | . . . | . . . | . . . | 35·3 | 56 | 18, 25 | 13 | 15 | 43·2 | 27·4 | 15·8 | 26·0 | 26 | 8·0 | 8 | . . . | . . . | 3·92 | . . . | . . |
| Centre, | State College— | | | | | | | | | | | | | | | | | | | | | |
| | Agricultural Experiment Station, | 1,191 | 30·028 | 30·603 | 29·359 | 33·1 | 58 | 17, 25 | 4 | 5 | 40·4 | 25·8 | 14·6 | 29·0 | 27 | 2·0 | 8 | 84·3 | 31·4 | 5·09 | 4·05 | 1·5 |
| Chester, | West Chester, | 455 | 30·100 | 30·695 | 29·497 | 37·8 | 64 | 18 | 11 | 5 | 45·5 | 29·9 | 15·6 | 29·0 | 26 | 4·0 | 7 | 73·0 | 30·0 | 5·92 | 4·25 | 1·0 |
| Chester, | Coatesville, | 380 | . . . | . . . | . . . | 35·9 | 67 | 18 | 6 | 28 | 46·3 | 27·4 | 18·9 | 36·0 | 28 | 5·0 | 7 | . . . | . . . | 5·31 | 6·00 | 3·0 |
| Chester,[1] | Kennett Square, | 275 | . . . | . . . | . . . | 36·6 | 60 | 18 | 14 | 5 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·84 | 3·00 | . . |
| Chester. | Phœnixville, | 183 | 30·131 | 30·699 | 29·492 | 38·8 | 63 | 25, 26 | 10 | 28 | 46·0 | 29·6 | 16·4 | 33·0 | 26 | 5·0 | 7 | 77·9 | 30·3 | 4·20 | 6·50 | . . |
| Chester, | Westtown, | 350 | 30·129 | 30·703 | 29·558 | 37·8 | 68 | 18 | 11 | 25 | 46·1 | 30·8 | 15·3 | 27·0 | 26 | 3·0 | 7 | . . . | . . . | 4·14 | 4·00 | 1·0 |
| Clarion, | Rimersburg, | 1,500 | . . . | . . . | . . . | 33·1 | 58 | 16 | 12 | 4 | 39·8 | 26·1 | 13·7 | 32·0 | 23 | 3·0 | 7 | . . . | . . . | . . . | . . . | . . |
| Clarion, | Clarion— | | | | | | | | | | | | | | | | | | | | | |
| | State Normal School, | 1,530 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 30·5 | 58 | 16 | — 2 | 5 | 37·4 | 24·0 | 13·4 | 32·0 | 5 | 2·0 | 8 | . . . | . . . | 7·01 | 13·50 | 6·0 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | 34·2 | 65 | 25 | 5 | 5 | 40·0 | 25·7 | 14·3 | 30·0 | 25 | 2·0 | 4 | . . . | . . . | 4·13 | 3·00 | 6·0 |
| Columbia, | Catawissa, | 491 | . . | . . . | . . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Crawford, | Meadville, | 1,320 | 30·136 | 30·770 | 29·580 | 32·9 | 55 | 25 | 3 | 5 | 40·2 | 24·3 | 15·9 | 36·0 | 3 | 3·0 | 1 | 82·0 | 27·8 | 6·65 | 5·75 | 4·0 |
| Cumberland, | Carlisle, | 480 | . . . | . . . | . . . | 35·6 | 67 | 17 | 9 | 5 | 43·9 | 28·5 | 15·4 | 26·0 | 6 | 4·0 | 7 | 84·0 | 29·0 | 4·22 | . . . | . . |
| Dauphin,[1] | Harrisburg, | 361 | 30·112 | 30·674 | 29·482 | 36·6 | 65 | 17 | 14 | 4, 5 | 43·3 | 29·9 | 13·4 | 24·0 | 15 | 5·0 | 9 | 72·0 | 28·0 | 3·31 | . . . | . |
| Delaware, | Swarthmore— | | | | | | | | | | | | | | | | | | | | | |
| | Swarthmore College, | 190 | 30·081 | 30·524 | 29·491 | 38·3 | 68 | 18 | 12 | 28 | 46·6 | 33·5 | 16·1 | 32·7 | 25 | 4·9 | 7 | 78·0 | 31·0 | 4·46 | 2·00 | . . |
| Erie,[1] | Erie, | 681 | 30·000 | 30·600 | 29·250 | 33·0 | 60 | 15 | 0 | 5 | 41·0 | 25·0 | 16·0 | 43·0 | 5 | 3·0 | 26 | 81·0 | 27·0 | 4·95 | . . | . . |
| Fayette, | Uniontown, | 1,000 | 30·019 | 30·475 | 29·477 | 32·9 | 68 | 20 | 10 | 5 | 48·5 | 31·3 | 17·2 | 37·0 | 20 | 4·0 | 10 | . . . | . . . | 6·64 | . . . | . . |
| Franklin,[1] | Chambersburg— | | | | | | | | | | | | | | | | | | | | | |
| | Wilson Female College, | 618 | 30·180 | 30·682 | 29·619 | 33·0 | 68 | 18 | 7 | 5 | 42·1 | 24·0 | 18·1 | 42·0 | 16 | 8·0 | 22 | 87·4 | 31·8 | 2·54 | . . . | . . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 38·2 | 67 | 17 | 10 | 5 | 47·5 | 30·1 | 17·4 | 26·0 | 6 | 6·0 | 7 | 77·4 | 30·6 | 4·64 | 1·00 | . . |
| Huntingdon,[1] | Huntingdon— | | | | | | | | | | | | | | | | | | | | | |
| | The Normal College, | 650 | . . . | . . . | . . . | 33·5 | 64 | 17, 18 | 5 | 5 | 44·1 | 28·1 | 16·0 | 33·0 | 15 | 4·0 | 27 | . . . | . . . | 4·84 | 2·50 | 1·0 |
| Huntingdon, | Petersburg, | 700 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . | . . . | . . . | . . . | . . . | . . . | . . |
| Indiana, | Indiana— | | | | | | | | | | | | | | | | | | | | | |
| | State Normal School, | 1,350 | 30·041 | 30·359 | 29·681 | 34·5 | 60 | 25 | 4 | 5 | 43·7 | 23·4 | 20·3 | 43·0 | 6 | 6·0 | 1 | 84·3 | 30·3 | 5·99 | 3·00 | 2·0 |
| Lancaster, | Lancaster (21 days).— | | | | | | | | | | | | | | | | | | | | | |
| | Franklin and Marshall College, | 411 | 30·128 | 30·705 | 29·253 | 37·2 | 66 | 17 | 14 | 5 | 48·8 | 28·3 | 20·5 | 36·5 | 13 | 9·5 | 10 | 86·0 | 35·1 | 3·01 | 3·00 | . . |
| Lawrence, | New Castle, | 932 | . . . | . . . | . . . | 38·3 | 64 | 20 | 5 | 4 | 45·6 | 24·9 | 20·7 | 40·0 | 20 | 7·0 | 21 | 90·7 | 30·0 | 3·87 | 2·00 | 1·5 |
| Lebanon, | Lebanon, | 474 | 30·119 | 30·684 | 29·496 | 37·7 | 64 | 17 | 16 | 28 | 45·2 | 29·5 | 15·7 | 27·4 | 26 | 7·6 | 9 | 77·9 | 31·1 | 3·33 | 2·50 | . . |
| Lehigh, | Coopersburg, | 520 | . . . | . . . | . . | 35·5 | 62 | 17 | 8 | 28 | 44·5 | 28·1 | 16·4 | 32·0 | 6 | 7·0 | 7 | . . . | . . . | 4·57 | 7·50 | 1·5 |
| Luzerne, | Drifton— | | | | | | | | | | | | | | | | | | | | | |
| | Drifton Hospital, | 1,655 | . . . | . . . | . . . | 31·6 | 56 | 16, 17 | 5 | 5 | 41·3 | 23·2 | 18·1 | 31·0 | 18 | 6·0 | 25 | . . . | . . . | 2·90 | 2·00 | . . |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . . | . . . | . . . | 34·7 | 58 | 25, 26 | 10 | 5 | 42·9 | 26·5 | 16·4 | 31·0 | 26 | 8·0 | 25 | . . . | . . . | 4·00 | 11·75 | 3·0 |
| Lycoming,[1] | Nisbet, | 550 | . . . | . . . | . . . | 33·9 | 60 | 25 | 14 | 4 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·20 | 15·00 | 2·0 |
| McKean, | Smethport, | 1,500 | . . . | . . . | . . . | 34·3 | 56 | 25 | 9 | 5 | 38·6 | 21·9 | 16·7 | 35·0 | 5 | 6·5 | 26 | . . . | . . . | . . . | . . . | . . |
| Mercer,[1] | Greenville— | | | | | | | | | | | | | | | | | | | | | |
| | Thiel College, | 1,000 | 30·004 | 30·574 | 29·306 | 34·6 | 61 | 21 | 5 | 4 | 43·7 | 25·6 | 18·1 | 35·0 | 15 | 5·9 | 8 | 94·3 | 30·4 | 2·50 | 6·50 | 2·0 |
| Mifflin, | Pottstown, | 150 | . . . | . . . | . . . | 37·7 | 62 | 17 | 13 | 5 | 44·5 | 30·9 | 13·6 | 27·0 | 28 | 2·0 | 7 | 78·0 | 31·0 | 4·05 | 3·00 | . . |
| Northampton, | Bethlehem, | 360 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Philadelphia,[1] | Philadelphia— | | | | | | | | | | | | | | | | | | | | | |
| | Signal Office, | 117 | 30·112 | 30·710 | 29·480 | 39·6 | 69 | 18 | 15 | 5 | 46·8 | 32·4 | 14·4 | 29·0 | 24 | 4·0 | 27 | 73·0 | 30·0 | 4·71 | 2·00 | . . |
| Philadelphia, | Philadelphia, | 120 | 30·116 | 30·710 | 29·490 | 40·5 | 70 | 18 | 17 | 5 | 48·4 | 32·6 | 15·8 | 29·0 | 24 | 8·0 | 12 | 80·6 | 32·9 | 5·32 | 3·25 | . . |
| Schuylkill, | Girardville, | 1,000 | 30·053 | 30·492 | 29·521 | 33·9 | 57 | 17 | 10 | 5 | 40·5 | 26·6 | 13·9 | 25·0 | 18 | 7·0 | 25 | . . . | . . . | 4·36 | 5·25 | 1·7 |
| Snyder, | Selins Grove, | 445 | . . . | . . | . . . | 34·1 | 55 | 25 | 5 | 18 | 39·0 | 29·2 | 9·8 | . . . | . . . | . . . | . . . | 87·0 | 30·0 | 3·09 | ·75 | ·7 |
| Somerset, | Somerset, | 2,250 | . . . | . . . | . . . | 31·6 | 63 | 17 | 0 | 4 | 49·4 | 24·1 | 18·3 | 33·0 | 15 | 9·0 | 3 | 88·6 | 34·1 | 5·50 | 4·00 | 2·5 |
| Sullivan, | Eagles Mere, | 2,060 | 30·169 | 30·646 | 29·566 | 26·8 | 47 | 25 | 0 | 5 | 32·1 | 21·6 | 10·5 | 20·0 | 5 | 3·0 | 26 | 77·2 | 20·6 | 5·46 | 12·50 | 11·5 |
| Tioga, | Wellsboro, | 1,327 | 30·042 | 30·632 | 29·431 | 29·7 | 54 | 25 | 5 | 4 | 37·0 | 24·0 | 13·0 | 22·0 | 3 | 4·0 | 9 | 77·0 | 27·1 | 3·46 | 9·25 | 3·5 |
| Union,[1] | Lewisburg, | 450 | . . . | . . . | . . . | 34·9 | 58 | 25 | 8 | 5 | 42·1 | 27·7 | 14·4 | 26·0 | 15 | 5·0 | 10 | . . . | . . . | 3·75 | 4·00 | 1·5 |
| Warren, | Columbus, | 1,410 | . . . | . . . | . . . | 32·4 | 56 | 15 | 2 | 5 | 40·0 | 24·8 | 15·2 | 42·0 | 15 | 4·0 | 22 | 66·0 | 19·5 | 6·67 | . . . | 3·0 |
| Washington, | Canonsburg, | 950 | . . . | . . . | . . . | . . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Wayne, | Dyberry, | 1,100 | . . . | . . . | . . . | 27·1 | 50 | 25 | — 7 | 5 | 35·8 | 18·4 | 17·4 | 38·0 | 15 | 5·0 | 20 | . . . | . . . | 4·07 | 17·50 | 12·0 |
| Wayne, | Honesdale, | 1,000 | . . . | . . . | . . . | 29·4 | 56 | 25 | — 3 | 5 | 37·8 | 21·0 | 16·8 | 38·0 | 15 | 6·0 | 16 | . . . | . . . | 3·45 | 3·00 | . . |
| Westmoreland, | Ligonier (26 days), | 1,750 | . . . | . . . | . . . | 38·2 | 61 | 16, 25 | 7 | 4, 5 | 45·3 | 30·7 | 18·6 | 41·0 | 15 | 4·0 | 26 | . . . | . . . | 8·29 | 1·50 | . . |
| Wyoming,[1] | South Eaton | 660 | . . . | . . . | . . . | 32·6 | 57 | 25 | 7 | 5 | 40·0 | 25·3 | 14·7 | 28·0 | 15 | 4·0 | 8 | . . . | . . . | 3·48 | 9·00 | . . |
| York,[1] | York, | 385 | 30·039 | 30·477 | 29·520 | 37·0 | 65 | 17 | . . . | . . . | 46·9 | 27·1 | 19·8 | . . . | . . . | . | . . . | 83·0 | 33·6 | 3·37 | 2·00 | . . |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

| Temperature. | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum. | | Mean of Maximum. | Mean of Minimum. | Daily Range. | | | | | | | | | | |
| Lowest. | Date. | | | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at End of Month. | Number of Days |
| 9 | 4 | 47·2 | 31·3 | 15·9 | 36·0 | 20 | 4·0 | 10 | 79·2 | 32·8 | 6·09 | 2·30 | 2·00 | 1 |
| 9 | 4 | 44·0 | 27·3 | 16·7 | 31·0 | 15 | 7·0 | 10 | 75·0 | 28·1 | 4·10 | 1·25 | . . . | 1 |
| 13 | 5 | 48·6 | 31·6 | 17·0 | 35·0 | 4 | 6·0 | 20 | 73·5 | 32·0 | 4·59 | . . . | . . . | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·13 | 16·00 | 34·00 | 1 |
| 6 | 5 | 43·4 | 26·8 | 16·6 | 31·0 | 6 | 5·0 | 7 | 77·0 | 29·0 | 3·92 | 4·75 | 1·25 | 1 |
| 3 | 5 | 38·4 | 23·0 | 15·4 | 33·0 | 15 | 6·5 | 4 | 79·7 | 26·1 | 2·71 | 6·03 | . . . | 1 |
| 3 | 5 | 35·1 | 23·3 | 11·8 | 24·0 | 15 | 4·0 | 9 | . . . | . . . | 3·13 | 12·30 | 1·00 | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·50 | . . . | . . . | 1 |
| 1 | 28 | 44·2 | 25·3 | 18·9 | 39·0 | 28 | 5·0 | 7 | 81·0 | 28·5 | 5·13 | 6·00 | 2·00 | 1 |
| 11 | 4 | 45·3 | 29·4 | 15·9 | 31·0 | 5 | 8·0 | 7 | 87·6 | 33·0 | 7·99 | . . . | 3·00 | 1 |
| 4 | 5 | 41·9 | 24·0 | 17·9 | 36·0 | 6 | 9·0 | 10 | . . . | . . . | 4·56 | 6·37 | . . . | 1 |
| 13 | 15 | 43·2 | 27·4 | 15·8 | 26·0 | 26 | 8·0 | 8 | . . . | . . . | 3·92 | . . . | . . . | |
| 4 | 5 | 40·4 | 25·8 | 14·6 | 29·0 | 27 | 2·0 | 8 | 84·3 | 31·4 | 5·29 | 4·05 | 1·80 | 1 |
| 11 | 5 | 45·5 | 29·9 | 15·6 | 29·0 | 26 | 4·0 | 7 | 73·0 | 30·0 | 5·92 | 4·25 | 1·00 | 1 |
| 6 | 28 | 46·3 | 27·4 | 18·9 | 36·0 | 28 | 5·0 | 7 | . . . | . . . | 5·31 | 6·00 | 3·00 | 1 |
| 14 | 5 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·84 | 3·00 | . . . | 1 |
| 10 | 28 | 46·0 | 29·6 | 16·4 | 35·0 | 26 | 5·0 | 7 | 77·9 | 30·3 | 4·20 | 0·50 | . . . | 1 |
| 11 | 25 | 46·1 | 30·8 | 15·3 | 27·0 | 26 | 3·0 | 7 | . . . | . . . | 4·14 | 4·00 | 1·00 | |
| 12 | 4 | 39·8 | 26·1 | 13·7 | 32·0 | 23 | 3·0 | 7 | . . . | . . . | . . . | . . . | . . . | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| — 2 | 5 | 37·4 | 24·0 | 13·4 | 32·0 | 5 | 2·0 | 8 | . . . | . . . | 7·01 | 13·50 | 6·00 | 1 |
| 5 | 5 | 40·0 | 25·7 | 14·3 | 30·0 | 25 | 2·0 | 4 | . . . | . . . | 4·13 | 3·00 | 6·00 | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 3 | 5 | 40·2 | 24·3 | 15·9 | 36·0 | 3 | 3·0 | 1 | 82·0 | 27·8 | 6·65 | 5·75 | 4·00 | 1 |
| 9 | 5 | 43·9 | 28·5 | 15·4 | 26·0 | 6 | 4·0 | 7 | 84·0 | 29·0 | 4·22 | . . . | ·50 | 1 |
| 14 | 4, 5 | 43·3 | 29·9 | 13·4 | 24·0 | 15 | 5·0 | 9 | 72·0 | 28·0 | 2·31 | . . . | . . . | 1 |
| 12 | 28 | 46·6 | 30·5 | 16·1 | 32·7 | 25 | 4·9 | 7 | 78·0 | 31·0 | 4·46 | 2·00 | . . . | 1 |
| 0 | 5 | 41·0 | 25·0 | 16·0 | 43·0 | 5 | 3·0 | 26 | 81·0 | 27·0 | 4·95 | . . | . . . | 1 |
| 10 | 5 | 48·5 | 31·3 | 17·2 | 37·0 | 20 | 4·0 | 10 | . . . | . . . | 6·64 | . . . | . . . | 1 |
| 7 | 5 | 42·1 | 24·0 | 18·1 | 42·0 | 16 | 8·0 | 20 | 87·4 | 31·8 | 2·54 | . . . | . . . | |
| 10 | 5 | 47·5 | 30·1 | 17·4 | 26·0 | 6 | 6·0 | 7 | 77·4 | 30·6 | 4·64 | 1·00 | . . . | |
| 5 | 5 | 44·1 | 28·1 | 16·0 | 33·0 | 15 | 4·0 | 27 | . . . | . . . | 4·84 | 2·50 | 1·00 | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 4 | 5 | 43·7 | 23·4 | 20·3 | 43·0 | 6 | 6·0 | 1 | 84·3 | 30·3 | 5·99 | 3·00 | 2·00 | 1 |
| 14 | 5 | 48·8 | 28·3 | 20·5 | 36·5 | 19 | 9·5 | 10 | 86·0 | 35·1 | 3·01 | 3·00 | . . . | |
| 5 | 4 | 45·6 | 24·9 | 20·7 | 40·0 | 20 | 7·0 | 21 | 90·7 | 36·0 | 3·87 | 2·00 | 1·50 | 1 |
| 16 | 28 | 45·2 | 29·5 | 15·7 | 27·4 | 26 | 7·6 | 9 | 77·9 | 31·1 | 3·33 | 2·50 | . . . | 1 |
| 8 | 28 | 44·5 | 28·1 | 16·4 | 32·0 | 6 | 7·0 | 7 | . . . | . . . | 4·57 | 7·50 | 1·50 | 1 |
| 5 | 5 | 41·3 | 23·2 | 18·1 | 31·0 | 18 | 6·0 | 25 | . . . | . . . | 2·90 | 2·00 | . . . | |
| 10 | 5 | 42·9 | 26·5 | 16·4 | 31·0 | 26 | 8·0 | 25 | . . . | . . . | 4·00 | 11·75 | 3·00 | 1 |
| 14 | 4 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·20 | 15·00 | 8·00 | |
| 9 | 5 | 38·6 | 21·9 | 16·7 | 35·0 | 5 | 6·5 | 26 | . . . | . . . | . . . | . . . | . . . | . . |
| 5 | 4 | 43·7 | 25·6 | 18·1 | 35·0 | 15 | 5·9 | 8 | 94·3 | 30·4 | 2·50 | 6·50 | 2·00 | 1 |
| 13 | 5 | 44·5 | 30·9 | 13·6 | 27·0 | 28 | 2·0 | 7 | 78·0 | 31·0 | 4·05 | 3·00 | . . . | 1 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| 15 | 5 | 46·8 | 32·4 | 14·4 | 29·0 | 24 | 4·0 | 27 | 73·0 | 30·0 | 4·71 | 2·00 | . . . | 1 |
| 17 | 5 | 48·4 | 32·6 | 15·8 | 29·0 | 24 | 8·0 | 12 | 80·6 | 32·9 | 5·32 | 3·25 | . . . | 1 |
| 10 | 5 | 40·5 | 26·6 | 13·9 | 25·0 | 18 | 7·0 | 25 | . . . | . . . | 4·36 | 5·25 | 1·75 | 1 |
| 5 | 18 | 39·0 | 29·2 | 9·8 | . . . | . . . | . . . | . . . | 87·0 | 30·0 | 3·09 | ·75 | ·75 | |
| 9 | 4 | 42·4 | 24·1 | 18·3 | 31·0 | 15 | 9·0 | 3 | 88·6 | 34·1 | 5·50 | 4·00 | 2·50 | 1 |
| 0 | 5 | 38·1 | 21·6 | 10·5 | 20·0 | 5 | 3·0 | 26 | 77·2 | 20·6 | 5·46 | 12·50 | 11·50 | 1 |
| 5 | 4 | 37·0 | 24·0 | 13·0 | 22·0 | 3 | 4·0 | 9 | 77·0 | 27·1 | 3·46 | 9·25 | 3·50 | 1 |
| 8 | 5 | 43·1 | 27·7 | 14·4 | 26·0 | 15 | 5·0 | 10 | . . . | . . . | 3·75 | 4·00 | 1·50 | |
| 9 | 5 | 40·0 | 24·8 | 15·2 | 42·0 | 15 | 4·0 | 22 | 66·0 | 19·5 | 6·67 | . . . | 3·00 | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| — 7 | 5 | 35·8 | 18·4 | 17·4 | 38·0 | 15 | 5·0 | 20 | . . . | . . . | 4·97 | 17·50 | 12·00 | 1 |
| — 3 | 5 | 37·8 | 21·0 | 16·8 | 38·0 | 15 | 6·0 | 16 | . . . | . . . | 3·45 | 3·00 | . . . | 1 |
| 7 | 4, 5 | 45·3 | 26·7 | 18·6 | 41·0 | 15 | 4·0 | 26 | . . . | . . . | 8·29 | 1·50 | . . . | 1 |
| 7 | 5 | 40·0 | 25·3 | 14·7 | 28·0 | 15 | 4·0 | 8 | . . . | . . . | 3·48 | 9·00 | . . . | 1 |
| . . . | . . . | 46·9 | 27·1 | 19·8 | . . . | . . . | . | . . . | 83·0 | 33·6 | 3·37 | 2·00 | . . . | 1 |

| IPITATION. | | Number of Days. | | | Wind. | | | Observers. |
|---|---|---|---|---|---|---|---|---|
| Depth of Snow on Ground at End of Month. | Number of Days Rainfall. | Clear. | Fair. | Cloudy. | Prevailing Direction. 7 A. M. | 2 P. M. | 9 P. M. | |
| 2·00 | 14 | 5 | 6 | 17 | NW | NW | NW | Oscar D. Stewart, Sgt. Sig. Corps. |
| . . . | 11 | 3 | 12 | 13 | SW | SW | SW | Miss E. A. G. Apple. |
| . . . | 13 | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| 34·00 | 13 | 5 | 5 | 18 | SW | NW | SW | A. H. Boyle. |
| 1·85 | 11 | 3 | 11 | 14 | W | W | W | Prof. J. A. Stewart. |
| . . . | 10 | 5 | 3 | 20 | SE | SW | S | Charles Beecher. |
| 1·00 | 14 | 3 | 7 | 18 | SW | SW | SW | Geo. W. T. Warburton |
| . . . | 14 | 7 | 11 | 10 | N | S | NW | J. C. Hilsman. |
| 2·00 | 16 | 5 | 8 | 15 | NW | NW | NW | J. L. Heacock. |
| 3·00 | 17 | 3 | 9 | 16 | S | S | S | E. C. Lorentz. |
| . . . | 13 | 4 | 9 | 15 | W | SE | W | T. B. Lloyd. |
| . . . | 8 | 4 | 7 | 7 | . . . | . . . | . . | John J. Boyd. |
| 1·80 | 13 | 3 | 9 | 16 | W | W | W | Prof. Wm. Frear. |
| 1·00 | 18 | 10 | 6 | 12 | NW | NW | W | Jesse C. Green, D.D.S. |
| 3·00 | 15 | 5 | 11 | 12 | W | W | W | W. T. Gordon. |
| . . . | 17 | 9 | 6 | 13 | NW | NW | NW | Benj. P. Kirk. |
| . . . | 15 | 5 | 8 | 15 | SE | . . . | NW | Knowles Croskey. |
| 1·00 | 9 | 7 | 7 | 14 | W | W | W | Prof. Wm. F. Wickersham. |
| . . . | 14 | 4 | 10 | 14 | W | W | W | Rev. W. W. Deatrick, A.M. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | C. M. Thomas, B.S. |
| 6·00 | 14 | 4 | 9 | 15 | W | W | SW | Nathan Moore. |
| 6·00 | 11 | 10 | 3 | 15 | W | W | W | Prof. John A. Robb. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| 4·00 | 14 | 2 | 11 | 15 | W | W | W | J. & B. H. Metcalf. |
| ·50 | 13 | 6 | 10 | 12 | W | W | N | J. E. Pague. |
| . . | 14 | 6 | 7 | 15 | NW | NW | NW | Frank Ridgway, Sgt. Sig. Corps. |
| . . . | 11 | . . . | 13 | 15 | NW | NW | NW | Prof. Susan J. Cunningham. |
| . . . | 19 | 3 | 7 | 18 | S | S | S | Peter Wood, Sgt. Sig. Corps. |
| . . . | 12 | 9 | 9 | 10 | . . . | . . . | . . . | Wm. Hunt. |
| . . . | 7 | 10 | 4 | 14 | . . . | . . . | . . . | Miss Mary A. Ricker. |
| . . . | 8 | 9 | 8 | 11 | NW | SW | W | Thomas F. Sloan. |
| 1·00 | 10 | 3 | 17 | 8 | W | W | W | Prof. W. J. Swigart. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | J. E. Rooney. |
| 2·00 | 13 | 4 | 9 | 15 | W | SW | S | Prof. S C. Schmucker. |
| . . . | 9 | 3 | 12 | 13 | SW | NW | SE | Lewis T. Lampe. |
| 1·50 | 12 | 3 | 9 | 16 | NW | NW | NW | Wm. T. Butz. |
| . . . | 12 | 1 | 12 | 8 | SW | SW | NW | Wm. H. Kline. |
| 1·50 | 13 | 6 | 10 | 12 | E | SW | SE | M. H. Boye. |
| . . . | 8 | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| 3·00 | 10 | 13 | . . . | 15 | NW | NW | NW | A. W Betterly. |
| 2·00 | 9 | 8 | . . | 20 | W | . . . | E | John S. Gibson, P. M. |
| . . . | . . . | . . . | . . . | . . . | W | W | W | Armstrong & Brownell. |
| 2·00 | 15 | 3 | 6 | 19 | SW | . . . | S | Prof S. H. Miller. |
| . . . | 10 | 9 | 10 | 9 | W | NW | S | Charles Moore, D.D.S. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Lerch & Rice. |
| . . . | 15 | 8 | 6 | 14 | NW | NW | NW | Luther M. Dey, Sgt. Sig. Corps. |
| . . . | 16 | 6 | 9 | 13 | NW | NW | NW | John Comly. |
| 1·75 | 13 | 8 | 8 | 12 | NW | NW | NW | E. C Wagner. |
| ·75 | 6 | 9 | 17 | 9 | NW | SW | SW | J. M. Boyer, |
| 2·50 | 13 | 1 | 8 | 19 | NW | NW | NW | W. M. Schrock. |
| 11·50 | 11 | 15 | 9 | 4 | SW | SW | SW | E. S. Chase. |
| 3·50 | 10 | 3 | 8 | 17 | S | S | S | H. D. Deming. |
| 1·50 | 8 | 8 | 10 | 10 | SW | SW | SW | F. O. Whitman. |
| 3·00 | 18 | 6 | 2 | 20 | SW | SW | SW | Wm. Loveland. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | A. L. Runion, M.D. |
| 12·00 | 15 | 4 | 8 | 16 | W | W | NW | Theodore Day. |
| . . . | 11 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| . . . | 11 | 9 | 2 | 17 | . . . | . . . | . . . | J. T. Ambrose. |
| . . . | 14 | 3 | 8 | 15 | NW | NW | NW | Benj. M. Hall. |
| . . . | 15 | 9 | 10 | 9 | NW | NW | NW | Mrs. L. H. Grenewald. |

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

*Coronæ.*—Charlesville, 16th, 17th, 18th; Blue Knob, 11th; Rimersburg, 27th; Lebanon, 11th, 14th, 15th, 16th, 18th, 19th, 22d; Dyberry, 15th.

*Solar Halos.*—Le Roy, 5th, 19th, 23d, 24th; Lebanon, 24th; Philadelphia, 19th, 23d, 24th, 28th; Eagles Mere, 5th, 6th, 23d; Dyberry, 19th, 23d.

*Lunar Halos.*—Charlesville, 11th, 14th; Phœnixville, 15th, 16th, 22d, 23d; Meadville, 13th, 15th, 19th, 21st; Carlisle, 15th, 18th; Lancaster, 22d; Lebanon, 15th; Nisbet, 18th; Greenville, 22d; Philadelphia, 15th, 16th, 22d; Dyberry, 15th.

*Meteors.*—Charlesville, 27th; Philadelphia, 1st.

*Zodiacal Lights.*—Charlesville, 5th; Coatesville, 4th, 8th.

## WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for January, 1891:

Weather, 88 per cent.

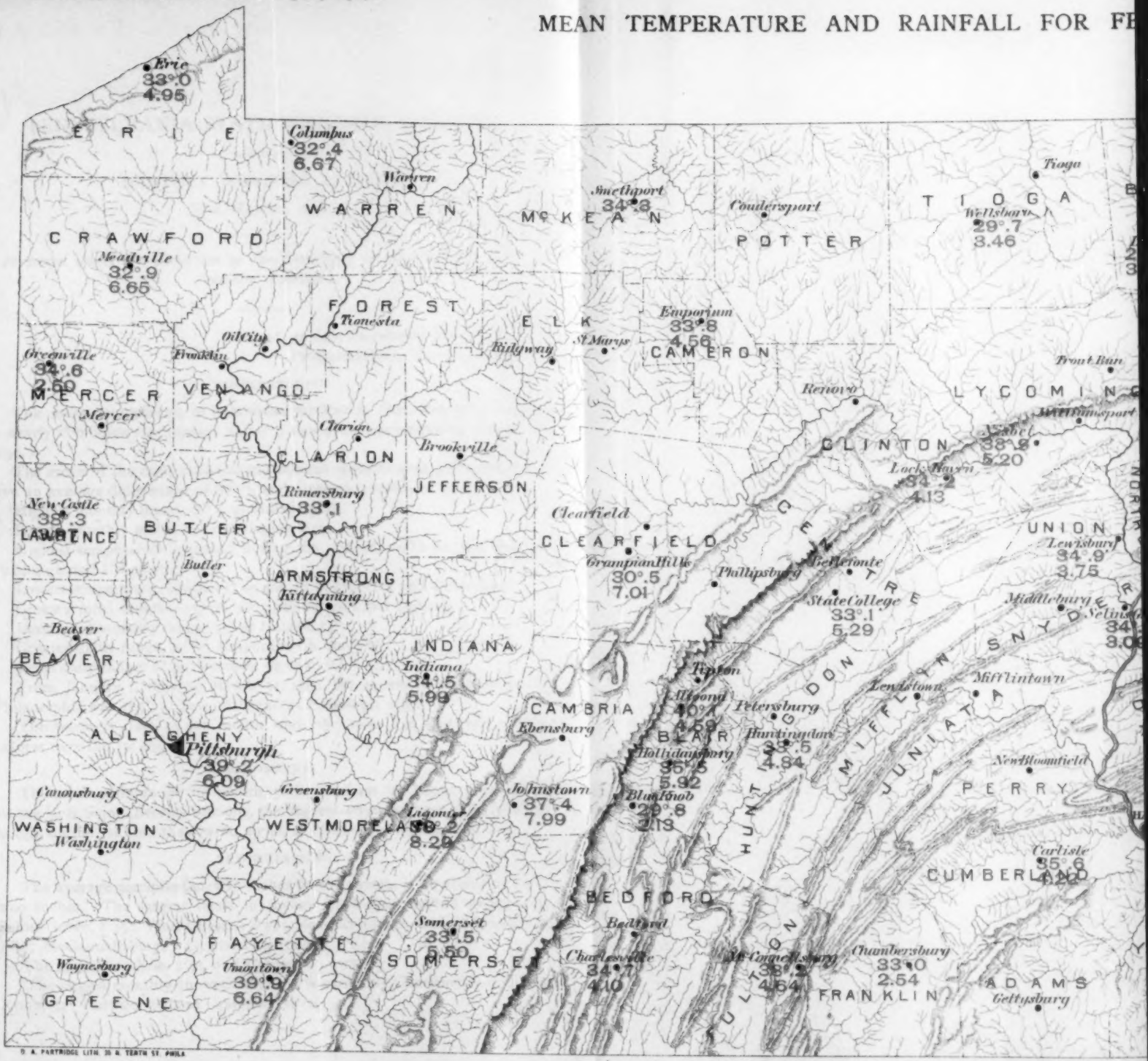
Temperature, 88 per cent.

## TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |

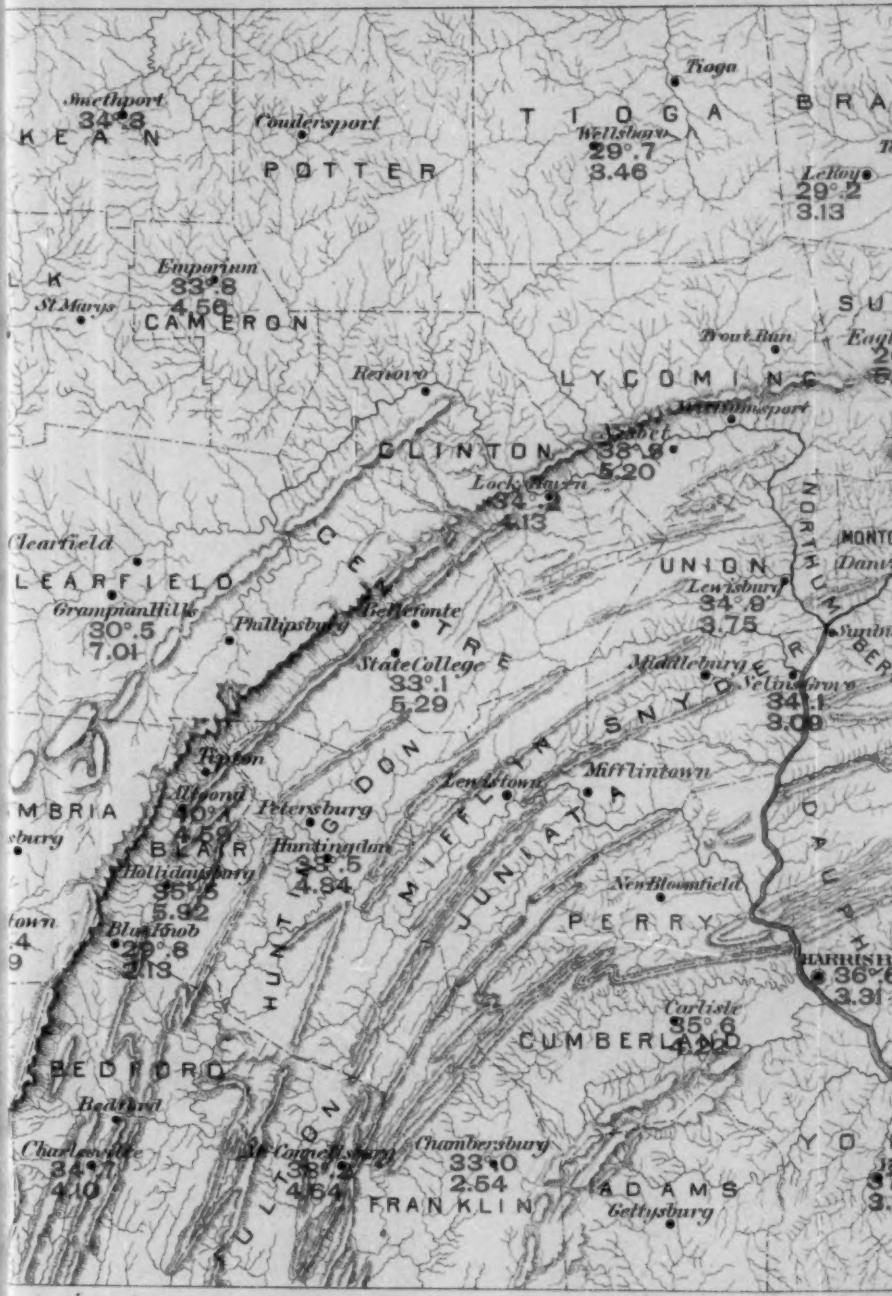
| *Displayman.* | *Station.* |
|---|---|
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
| Robt. M. Graham, | Catawissa. |
| Henry F. Bitner, | Millersville. |
| A. M. Wildman, | Langhorne. |
| G. W. Klee, | Chambersburg. |
| A. Simon's Sons, | Lock Haven. |
| *Raftsman's Journal*, | Clearfield. |
| R. C. Schmidt & Co., | Belle Vernon. |
| Chas. B. Lutz, | Bloomsburg. |
| E. C. Lorentz, | Johnstown. |
| W. M. James, | Ashland. |
| Miller & Allison, | Punxsutawney. |
| E. J. Sellers, | Kutztown. |
| H. M. Kaisinger, | Hartsville. |
| Foulk & Co., | Milford. |
| William Lawton, | Wilmington, Del. |
| Wister Heberton & Co., | Germantown. |
| Charles M. Mullen, | Bedford. |
| E. W. Merrill, | North East. |
| A. Simon's Sons, | Lock Haven. |
| Frank Ridgway, | Harrisburg. |
| G. W. Yost, | Collegeville. |
| A. H. Gerbench, | Annville. |
| Knowles Croskey, | Phoenixville. |
| Powell Bros., | Shadeland. |
| Lincoln E. Rowley, | Athens. |
| P. S. Weber, | Du Bois. |
| E. Jennet, | Franklin. |
| Milton C. Cooper, | Ashbourne. |
| J. L. Long, | Freeport. |
| J. H. Apple, | Clarion. |
| George Wheeler, | Doylestown. |
| J. C. McCloskey, | Lock Haven. |
| Charles Petersen, | Honesdale. |
| Armstrong & Brownell, | Smethport. |

# MEAN TEMPERATURE AND RAINFALL FOR FE




C. A. PARTRIDGE LITH. 30 S. TENTH ST. PHILA

# MEAN TEMPERATURE AND RAINFALL FOR FEBRU



FEBRUARY. 1891.

State Weather Service.

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW.

FOR MARCH, 1891.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 31, 1891.

### TEMPERATURE.

The mean temperature of 53 stations for March, 1891, was 34°·1, which is nearly 2°·0 below the normal, and 0°·7 above the corresponding month of 1890.

The mean of the daily maxima and minima temperatures 42°·0 and 25°·7 give an average daily range of 16°·3, and a monthly mean of 33°·8.

Highest monthly mean, 38°·4 at Philadelphia.

Lowest monthly mean, 29°·1 at Eagles Mere.

Highest temperature recorded during the month, 60°·0 on the 18th at Pittsburgh and Uniontown.

Lowest temperature, minus 14° on the 2d at Dyberry and Columbus.

Greatest local monthly range, 70° at Smethport and Dyberry.

Least local monthly range, 43° at Harrisburg.

Greatest daily range, 42° at Emporium on the 30th.

Least daily range, 1° at Pottstown on the 27th.

From January 1, 1891, to March 31, 1891, the excess in temperature at Philadelphia was 185°, at Erie 261°, and at Pittsburgh 258°.

The warmest days of the month were the 18th, 23d and 30th. The coldest were the 1st and 2d.

### BAROMETER.

The mean pressure for the month, 30·10, is about ·08 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·63, at Pittsburgh, on the 1st, and the lowest, 29·36, at Pittsburgh, on the 13th.

### PRECIPITATION.

The average precipitation, 5·10 inches for the month, is an excess of about 2·00 inches. The largest totals in inches (including melted snow) were Selins Grove, 8·39; West Chester, 8·33; Kennett Square, 8·04; Charlesville, 7·89; McConnellsburg, 7·45, and Phœnixville, 7·42.

The least were Erie, 2·44, and Columbus, 2·72.

The largest monthly snowfall totals in inches were Charlesville, 39; Blue Knob, 34; Carlisle, 33, and Grampian Hills, 31.

The snow storm of the 27th was very severe in the Schuylkill and Lebanon valleys. Heavy drifts occurred and caused delay to traffic. The snow soon melted and very little was left on the ground at the end of the month.

### WIND AND WEATHER.

The prevailing wind was from the Northeast. The month was cold, wet, and generally unpleasant and unhealthy. Vegetation is backward. The prospects for grain and fruit are favorable.

Average number: Rainy days, 14; clear days, 7; fair days, 8; cloudy days, 16.

### MISCELLANEOUS PHENOMENA.

*Thunder-storms.*—Quakertown, 9th; Phœnixville, 9th; Carlisle, 9th; Coopersburg, 9th; Wilkes-Barre, 9th; Pottstown, 9th; Philadelphia, 9th.

*Hail.*—Blue Knob, 20th; Le Roy, 20th; Mauch Chunk, 15th, 20th; Phœnixville, 20th; Lock Haven, 14th; Carlisle, 20th; Swarthmore, 9th; Wellsboro, 20th; Lewisburg, 13th, 20th.

*Snow.*—Charlesville, 2d, 3d, 4th, 6th, 13th, 14th, 20th, 27th, 28th; Blue Knob, 2d, 3d, 4th, 6th, 7th, 9th, 10th, 13th, 14th, 15th, 16th, 20th, 22d, 27th, 28th, 31st; Hollidaysburg, 2d, 3d, 4th, 6th, 9th, 13th, 14th, 20th, 22d, 27th, 28th; Wysox, 2d, 3d, 6th, 20th, 31st; Le Roy, 3d, 4th, 6th, 16th, 20th, 21st, 27th; Quakertown, 3d, 4th, 6th, 14th, 21st, 31st; Johnstown, 2d, 3d, 4th, 6th, 9th, 13th, 16th, 20th, 27th, 28th; Emporium, 4th, 20th, 27th, 28th; State College, 2d, 6th, 9th, 13th, 14th, 20th, 21st, 27th, 28th, 31st; Coatesville, 1st, 3d, 6th, 14th, 20th, 28th, 29th; Kennett Square, 3d, 20th, 27th, 28th; Phœnixville, 3d, 6th, 7th, 14th, 31st; Westtown, 2d, 3d, 6th, 20th, 27th, 28th; Rimersburg, 2d, 3d, 4th, 6th, 9th, 14th, 22d, 27th, 28th; Grampian Hills, 3d, 4th, 6th, 9th, 13th, 14th, 20th, 27th, 31st; Meadville, 3d, 4th, 13th, 14th, 27th, 28th; Carlisle, 6th, 27th, 28th; Swarthmore, 3d, 28th; Uniontown, 2d, 9th, 13th, 14th, 27th, 28th; Huntingdon, 2d, 3d, 4th, 27th, 28th; Indiana, 2d, 3d, 4th, 6th, 13th, 16th, 27th, 28th; Lancaster, 3d, 4th, 27th, 28th; New Castle, 2d, 4th, 9th, 14th, 27th, 28th; Lebanon, 3d, 4th, 7th, 20th, 27th, 28th; Coopersburg, 3d, 4th, 6th, 21st, 31st; Wilkes-Barre, 4th, 20th; Smethport, 2d, 3d, 4th, 6th, 13th, 14th, 20th, 27th; Greenville, 1st, 2d, 3d, 4th, 5th, 6th, 9th, 13th, 14th, 15th, 16th, 19th, 27th, 28th; Pottstown, 3d, 27th; Philadelphia, 3d, 4th, 6th, 7th, 14th, 27th, 28th; Girardville, 2d, 3d, 4th, 20th, 27th, 31st; Selins Grove, 2d, 3d, 4th, 27th, 28th; Somerset, 3d, 4th, 7th, 27th, 28th; Eagles Mere, 4th, 5th, 6th, 7th, 13th, 14th, 20th, 21st, 27th, 31st; Lewisburg, 3d, 6th, 20th, 27th, 31st; Dyberry, 3d, 4th, 5th, 7th, 14th, 16th, 19th, 29th; Honesdale, 3d, 4th, 31st; Ligonier, 2d, 3d, 14th, 27th, 28th; South Eaton, 3d, 4th, 20th, 21st; York, 3d, 4th, 7th, 14th, 21st, 27th, 28th.

*Frost.*—Charlesville, 24th; Hollidaysburg, 6th, 11th, 17th, 18th, 26th, 30th; Quakertown, 10th, 11th, 30th; State College, 6th, 11th, 17th, 26th, 30th; Phœnixville, 10th, 15th, 19th, 30th; Westtown, 11th; Grampian Hills, 6th; Meadville, 30th; Lancaster, 11th; New Castle, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 9th, 10th, 11th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 24th, 25th, 26th, 27th,

# Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service

| County. | Station. | Elevation above Sea Level (feet). | Barometer Reduced to Sea Level. | | | Temperature. | | | | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maximum. | | Minimum. | | | | Daily Range. | | | | | | | | | |
| | | | Mean. | Highest. | Lowest. | Mean. | Highest. | Date. | Lowest. | Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at ... |
| Allegheny,[1] | Pittsburgh, | 847 | 30·100 | 30·630 | 29·360 | 37·6 | 65 | 18 | 11 | 1 | 44·5 | 29·8 | 14·7 | 30·0 | 17 | 6·0 | 4 | 71·6 | 27·8 | 3·11 | 7·60 | . . |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 32·8 | 57 | 18 | — 3 | 6 | 40·8 | 24·8 | 16·0 | 33·0 | 18 | 6·0 | 8 | 75·0 | 25·5 | 7·80 | 39·00 | . . |
| Berks, | Reading, | 280 | . . . | . . . | . . . | 38·6 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·35 | 3·27 | . . |
| Blair,[2] | Altoona, | 1,181 | . . . | . . . | . . . | 30·8 | 60 | 19 | 23 | 1, 2 | 48·0 | 31·6 | 16·4 | 31·0 | 17 | 5·0 | 24 | 65·5 | 29·0 | 2·62 | . . . | . . |
| Blair, | Blue Knob, | 2,500 | . . . | . . . | . . . | 28·2 | 56 | 18 | — 5 | 1 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·56 | 34·00 | 24·00 |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 33·9 | 61 | 18 | 2 | 1, 6 | 42·2 | 24·2 | 18·0 | 36·0 | 30 | 6·0 | 8 | 75·0 | 26·5 | 5·60 | 18·25 | . . |
| Bradford, | Wysox, | 718 | 30·139 | 30·599 | 29·420 | 32·6 | 56 | 30 | 2 | 2 | 40·1 | 24·3 | 15·8 | 27·0 | 11 | 3·0 | 20 | 74·5 | 24·7 | 3·12 | 13·00 | . . |
| Bradford, | Le Roy, | 1,400 | . . . | . . . | . . . | 29·9 | 52 | 30 | — 2 | 2 | 37·3 | 23·6 | 13·7 | 27·0 | 17 | 2·0 | 31 | . . . | . . . | 3·15 | 12·20 | . . |
| Bucks, | Forks of Neshaminy, | . . . | . . . | . . . | . . . | 36·3 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·61 | . . . | . . |
| Bucks, | Quakertown, | 536 | 30·120 | 30·600 | 29·670 | 34·4 | 63 | 23 | 5 | 2 | 43·8 | 25·5 | 18·3 | 35·0 | 30 | 7·2 | 21 | 77·0 | 27·1 | 5·59 | 3·75 | . . |
| Cambria,[1] | Johnstown, | 1,184 | 30·150 | 30·660 | 29·490 | 35·2 | 61 | 30 | 6 | 1 | 43·2 | 27·3 | 15·9 | 38·0 | 18 | 2·0 | 8 | 74·0 | 27·0 | 4·99 | 17·00 | . . |
| Cameron, | Emporium (30 days), | 1,030 | . . . | . . . | . . . | 35·7 | 69 | 18, 30 | — 4 | 1, 2 | 43·3 | 23·9 | 19·4 | 42·0 | 30 | 6·0 | 8 | . . . | . . . | 5·12 | 16·50 | . . |
| Carbon,[1] | Mauch Chunk (28 days), | 550 | . . . | . . . | . . . | 34·9 | . . . | . . . | . . . | . . . | 43·0 | 26·8 | 16·2 | . . . | . . . | . . . | . . . | . . . | . . . | 5·69 | . . . | . . |
| Centre, | State College—Agricultural Experiment Station, | 1,191 | 30·077 | 30·588 | 29·381 | 31·6 | 54 | 28, 30 | 0 | 2 | 38·6 | 24·2 | 14·4 | 29·0 | 30 | 2·0 | 8 | 84·6 | 27·3 | 4·07 | 15·05 | . . |
| Chester, | West Chester, | 455 | 30·094 | 30·523 | 29·432 | 35·2 | 61 | 23 | 10 | 2 | 42·8 | 28·5 | 14·3 | 27·0 | 18 | 4·5 | 27 | . . . | . . . | 8·33 | 18·50 | . . |
| Chester, | Coatesville, | 380 | . . . | . . . | . . . | 34·6 | 61 | 23 | 10 | 2 | 43·5 | 27·1 | 16·4 | 31·0 | 11 | 5·0 | 8 | . . . | . . . | 7·61 | 25·95 | . . |
| Chester,[1] | Kennett Square, | 375 | . . . | . . . | . . . | 34·5 | 54 | 24 | 13 | 2 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 8·04 | 19·50 | . . |
| Chester, | Phœnixville, | 183 | 30·124 | 30·579 | 29·569 | 36·8 | 62 | 23 | 12 | 3 | 44·2 | 29·4 | 14·8 | 25·0 | 29 | 5·0 | 8 | 82·6 | 29·7 | 7·42 | 11·60 | . . |
| Chester, | Westtown, | 350 | 30·149 | 30·585 | 29·548 | 36·2 | 62 | 23 | 11 | 2 | 43·7 | 30·1 | 13·6 | 25·0 | 11 | 2·5 | 27 | . . . | . . . | 5·38 | 13·50 | . . |
| Clarion, | Rimersburg, | 1,500 | . . . | . . . | . . . | 31·7 | 60 | 18 | 2 | 1, 6 | 38·9 | 24·3 | 14·6 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 15·00 | . . |
| Clarion, | Clarion—State Normal School, | 1,530 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 29·9 | 58 | 18 | — 2 | 6 | 37·4 | 22·5 | 14·9 | 36·0 | 18 | 4·0 | 27 | . . . | . . . | 3·27 | 31·00 | 4·00 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | 34·5 | 62 | 30 | 0 | 1 | 41·2 | 25·5 | 15·7 | 35·0 | 30 | 3·0 | 20 | . . . | . . . | 4·06 | 21·50 | . . |
| Columbia, | Catawissa, | 491 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Crawford, | Meadville, | 1,300 | 30·252 | 30·750 | 29 660 | 31·4 | 62 | 18 | 1 | 6 | 40·2 | 22·9 | 17·3 | 33·0 | 6 | 5·0 | 20 | 85·0 | 26·6 | 3·37 | 11·50 | . . |
| Cumberland, | Carlisle, | 480 | . . . | . . . | . . . | 33·8 | 58 | 30 | 10 | 6 | 41·8 | 27·1 | 14·7 | 32·0 | 30 | 3·0 | 8 | 83·0 | 28·0 | 6·52 | 33·25 | . . |
| Dauphin,[1] | Harrisburg, | 361 | 30·124 | 30·621 | 29·620 | 34·6 | 53 | 19, 23, 26 | 10 | 2 | 41·1 | 28·8 | 12·3 | 26·0 | 11 | 3·0 | 8 | 72·4 | 25·0 | 4·25 | 22·00 | 8·00 |
| Delaware, | Swarthmore—Swarthmore College, | 190 | 30·087 | 30·512 | 29·511 | 36·8 | 62 | 23 | 11 | 17 | 44·0 | 29·2 | 14·8 | 26·4 | 17 | 3·8 | 27 | 78·0 | 30·0 | 5·78 | 9·00 | . . |
| Erie,[1] | Erie, | 681 | 30·060 | 30·570 | 29·460 | 33·0 | 58 | 18 | 7 | 4 | 41·0 | 24·0 | 17·0 | 37·0 | 17 | 4·0 | 25 | 81 0 | 25·0 | 2·44 | . . | . . |
| Fayette, | Uniontown, | 1,000 | 30·099 | 30·512 | 29·558 | 38·0 | 65 | 18 | 2 | 1 | 46·5 | 29·5 | 17·0 | 34·0 | 18 | 5·0 | 23 | . . . | . . . | 4·22 | 3·20 | . . |
| Franklin,[1] | Chambersburg—Wilson Female College, | 618 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 34·4 | 58 | 25 | 7 | 6 | 43·5 | 26·3 | 17·2 | 34·0 | 30 | 5·0 | 8 | 82·0 | 29·3 | 7·45 | 24·00 | 4·00 |
| Huntingdon,[1] | Huntingdon—The Normal College, | 650 | . . . | . . . | . . . | 32·5 | 60 | 18,19,30 | 5 | 1, 6 | 42·0 | 23·0 | 19·0 | 39·0 | 18 | 5·0 | 8 | . . . | . . . | 4·48 | . . . | . . |
| Huntingdon, | Petersburg, | 700 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Indiana, | Indiana—State Normal School (30 days), | 1,350 | 30·048 | 30·503 | 29·547 | 34·1 | 63 | 18 | — 5 | 1 | 42·3 | 23·0 | 19·3 | 37·0 | 18 | 5·0 | 20 | 81·9 | 29·3 | 3·50 | 4·05 | . . |
| Lancaster, | Lancaster—Franklin and Marshall College, | 413 | 30·132 | 30·643 | 29·257 | 35·5 | 57 | 23 | 10 | 3 | 45·3 | 25·2 | 20·1 | 33·5 | 18 | 8·0 | 21 | 81·5 | 34·1 | 6·30 | 21·00 | . . |
| Lawrence, | New Castle, | 932 | . . . | . . . | . . . | 36·4 | 64 | 18 | — 2 | 1 | 42·9 | 24·5 | 18·4 | 33·0 | 30 | 6·0 | 22 | 84·7 | 35·4 | 3·32 | 5·25 | . . |
| Lebanon, | Lebanon, | 474 | 30·122 | 30·586 | 29·449 | 35·2 | 58 | 23 | 10 | 2 | 43·2 | 27·4 | 15·8 | 27·6 | 30 | 6·3 | 8 | 75·7 | 27·7 | 5·30 | 15·70 | . . |
| Lehigh, | Coopersburg, | 520 | . . . | . . . | . . . | 35·0 | 63 | 30 | 8 | 2 | 42·6 | 27·7 | 14·9 | 34·0 | 30 | 3·0 | 20 | . . . | . . . | 6·54 | 6·50 | ·60 |
| Luzerne, | Drifton—Drifton Hospital, | 1,655 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . . | . . . | . . . | 36·1 | 61 | 30 | 5 | 2 | 45·6 | 26·6 | 19·0 | 30·0 | 14 | 10·0 | 21 | . . . | . . . | 3·67 | 10·00 | . . |
| Lycoming,[1] | Nisbet, | 550 | . . . | . . . | . . . | 34·8 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·20 | 20·00 | . . |
| McKean, | Smethport, | 1,500 | . . . | . . . | . . . | 31·9 | 61 | 18 | — 9 | 2 | 40·1 | 21·2 | 18·9 | 38·5 | 30 | 6·0 | 27 | . . . | . . . | . . . | 22·00 | . . |
| Mercer,[1] | Greenville—Thiel College, | 1,000 | 30·045 | 30·577 | 29·335 | 33·0 | 63 | 18 | 0 | 1 | 41·8 | 24·2 | 17·6 | 30·5 | 18 | 4·4 | 14 | 92·6 | 28·0 | 3·33 | 18·00 | . . |
| Mifflin, | Pottstown, | 150 | . . . | . . . | . . . | 36·9 | 61 | 30 | 10 | 2 | 43·0 | 30·0 | 13·0 | 27·0 | 11 | 1·0 | 27 | 74·5 | 28·5 | 6·60 | 8·00 | . . |
| Northampton, | Bethlehem, | 360 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Philadelphia,[1] | Philadelphia—Signal Office, | 117 | 30·109 | 30·580 | 29·540 | 38·0 | 61 | 23, | 12 | 2 | 45·2 | 30·9 | 14·3 | 24·0 | 9 | 6·0 | 20 | 70·0 | 26·0 | 4·42 | 4·70 | . . |
| Philadelphia, | Philadelphia, | 120 | 30·114 | 30·590 | 29·550 | 38·4 | 62 | 23, 30 | 13 | 2 | 46·1 | 30·8 | 15·3 | 26·0 | 30 | 6·5 | 20 | 78·0 | 30·1 | 5·76 | 5·00 | . . |
| Schuylkill, | Girardville, | 1,000 | 30·085 | 30·525 | 29·570 | 33·1 | 53 | 28, 29 | 7 | 2 | 41·0 | 25·0 | 16·0 | 29·0 | 30 | 7·0 | 8 | . . . | . . . | 3·80 | 11·00 | . . |
| Snyder, | Selins Grove, | 445 | 30·144 | 30·537 | 29·522 | 34·2 | 59 | 11 | . . | . . . | 42·2 | 26·2 | 16·0 | . . . | . . . | . . . | . . . | 81·2 | 29·2 | 8·39 | 25·25 | . . |
| Somerset, | Somerset, | 2,250 | . . . | . . . | . . . | 30·1 | 63 | 25 | — 2 | 6 | 41·2 | 21·8 | 19·4 | 40·0 | 17 | 8·0 | 15 | 92·1 | 31·1 | 5·17 | 23·00 | . . |
| Sullivan, | Eagles Mere, | 2,000 | 30·195 | 30·603 | 29·403 | 29·1 | 48 | 23 | —12 | 2 | 34·8 | 20·7 | 14·1 | 30·0 | 2 | 4·0 | 31 | 72·6 | 20·1 | 5·68 | 14·25 | 3·00 |
| Tioga, | Wellsboro, | 1,327 | 30·088 | 30·578 | 29·334 | 30·2 | 56 | 30 | — 8 | 2 | 37·6 | 23·5 | 14·1 | 31·0 | 30 | 4·0 | 12 | 76·4 | 38·2 | 2·72 | 7·50 | . . |
| Union,[1] | Lewisburg, | 450 | . . . | . . . | . . . | 35·0 | 60 | 30 | 6 | 2 | 42·9 | 27·2 | 15·7 | 34·0 | 30 | 5·0 | 9 | . . . | . . . | 6·40 | 27·60 | 1·00 |
| Warren, | Columbus, | 1,410 | . . . | . . . | . . . | 31·0 | 62 | 30 | —14 | 2 | 40·6 | 22·0 | 18·6 | 41·0 | 6 | 2·0 | 31 | . . . | . . . | 2·72 | . . . | . . |
| Washington, | Canonsburg, | 950 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . |
| Wayne, | Dyberry, | 1,100 | . . . | . . . | . . . | 30·2 | 56 | 30 | —14 | 2 | 38·4 | 22·1 | 16·3 | 34·0 | 2 | 4·0 | 20 | . . . | . . . | 4·19 | 11·00 | 3·00 |
| Wayne, | Honesdale, | 1,000 | . . . | . . . | . . . | 32·4 | 58 | 23 | — 7 | 2 | 40·5 | 24·3 | 16·2 | 32·0 | 11 | 6·0 | 20 | . . . | . . . | 4·32 | 10·50 | 3·50 |
| Westmoreland, | Ligonier, | 1,750 | . . . | . . . | . . . | 36·3 | 64 | 18 | — 4 | 1 | 44·3 | 24·4 | 19·9 | 37·0 | 30 | 6·0 | 20 | . . . | . . . | 4·50 | 8·50 | . . |
| Wyoming,[1] | South Eaton | 660 | . . . | . . . | . . . | 33·8 | 58 | 30 | 0 | 2 | 41·2 | 26·5 | 14·7 | 22·0 | 26 | 5·0 | 12 | . . . | . . . | 4·54 | 15 00 | . . |
| York,[1] | York, | 385 | 30·044 | 30·528 | 29·535 | 34·9 | 57 | 30 | 10 | 2 | 43·8 | 26·0 | 17·8 | 38·0 | 30 | 7·0 | 8 | 86·4 | 29·6 | 6·07 | 24·00 | 2·00 |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

# BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR MARCH

| TEMPERATURE. | | | | | | | | | | | PRECIPITATION. | | | | NU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INIMUM. | | | | DAILY RANGE. | | | | | | | | | | | |
| Date. | Mean of Maximum. | Mean of Minimum. | Mean. | Greatest. | Date. | Least. | Date. | Relative Humidity. | Dew Point. | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at End of Month. | Number of Days Rainfall. | Clear. |
| 1 | 44·5 | 29·8 | 14·7 | 30·0 | 17 | 6·0 | 4 | 71·6 | 27·8 | 3·11 | 7·60 | . . . | 17 | 6 |
| 6 | 40·8 | 24·8 | 16·0 | 33·0 | 18 | 6·0 | 8 | 75·0 | 25·5 | 7·89 | 39·00 | . . . | 15 | 7 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·35 | 3·27 | . . . | 16 | . . . |
| 1, 2 | 48·0 | 31·6 | 16·4 | 31·0 | 17 | 5·0 | 24 | 65·5 | 29·0 | 2·62 | . . . | . . . | 16 | . . . |
| 1 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·56 | 34·00 | 24·00 | 19 | 5 |
| 1, 6 | 42·2 | 24·2 | 18·0 | 36·0 | 30 | 6·0 | 8 | 75·0 | 26·5 | 5·60 | 18·25 | . . . | 15 | 9 |
| 2 | 40·1 | 24·3 | 15·8 | 27·0 | 11 | 3·0 | 20 | 74·5 | 24·7 | 3·12 | 13·00 | . . . | 11 | 8 |
| 2 | 37·3 | 23·6 | 13·7 | 27·0 | 17 | 2·0 | 31 | . . . | . . . | 3·15 | 12·20 | . . . | 13 | 8 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·61 | . . . | . . . | 14 | 14 |
| 2 | 43·8 | 25·5 | 18·3 | 35·0 | 30 | 7·2 | 21 | 77·0 | 27·1 | 5·59 | 3·75 | . . . | 12 | 5 |
| 1 | 43·2 | 27·3 | 15·9 | 38·0 | 18 | 2·0 | 8 | 74·0 | 27·0 | 4·99 | 17·00 | . . . | 21 | 7 |
| 1, 2 | 43·3 | 23·9 | 19·4 | 42·0 | 30 | 6·0 | 8 | . . . | . . . | 5·12 | 16·50 | . . . | 11 | 7 |
| . . . | 43·0 | 26·8 | 16·2 | . | . . . | . . . | . . . | . . . | . . . | 5·69 | . . . | . . . | 8 | 11 |
| 2 | 38·6 | 24·2 | 14·4 | 29·0 | 30 | 2·0 | 8 | 84·6 | 27·3 | 4·07 | 15·05 | . . . | 14 | 4 |
| 2 | 42·8 | 28·5 | 14·3 | 27·0 | 18 | 4·5 | 27 | . . . | . . . | 8·33 | 18·50 | . . . | 15 | 11 |
| 2 | 43·5 | 27·1 | 16·4 | 31·0 | 11 | 5·0 | 8 | . . . | . . . | 7·01 | 25·95 | . . . | 15 | 9 |
| 2 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 8·04 | 19·50 | . . . | 17 | 9 |
| 3 | 44·2 | 29·4 | 14·8 | 23·0 | 29 | 5·0 | 8 | 82·6 | 29·7 | 7·42 | 11·00 | . . . | 14 | 8 |
| 2 | 43·7 | 30·1 | 13·6 | 25·0 | 11 | 2·5 | 27 | . . . | . . . | 5·38 | 13·50 | . . . | 12 | 9 |
| 1, 6 | 38·9 | 24·3 | 14·6 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 15·00 | . . . | 16 | 5 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 6 | 37·4 | 22·5 | 14·9 | 36·0 | 18 | 4·0 | 27 | . . . | . . . | 3·97 | 31·00 | 4·00 | 14 | 3 |
| 1 | 41·2 | 25·5 | 15·7 | 35·0 | 30 | 3·0 | 20 | . . . | . . . | 4·06 | 21·50 | . . . | 16 | 12 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 6 | 40·2 | 22·9 | 17·3 | 33·0 | 6 | 5·0 | 20 | 85·0 | 26·6 | 3·37 | 11·50 | . . . | 10 | 3 |
| 6 | 41·8 | 27·1 | 14·7 | 32·0 | 30 | 3·0 | 8 | 83·0 | 28·0 | 6·52 | 33·25 | . . . | 17 | 9 |
| 2 | 41·1 | 28·8 | 12·3 | 26·0 | 11 | 3·0 | 8 | 71·4 | 25·0 | 4·25 | 22·00 | 8·00 | 15 | 11 |
| 17 | 44·0 | 29·2 | 14·8 | 26·4 | 17 | 3·8 | 27 | 78·0 | 30·0 | 5·78 | 9·00 | . . . | 10 | 2 |
| 4 | 41·0 | 24·0 | 17·0 | 37·0 | 17 | 4·0 | 25 | 81·0 | 25·0 | 2·44 | . . . | . . . | 19 | 5 |
| 1 | 46·5 | 29·5 | 17·0 | 34·0 | 18 | 5·0 | 23 | . . . | . . . | 4·22 | 3·20 | . . . | 12 | 8 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 6 | 43·5 | 26·3 | 17·2 | 34·0 | 30 | 5·0 | 8 | 82·0 | 29·3 | 7·45 | 24·00 | 4·00 | 13 | 9 |
| 1, 6 | 42·0 | 23·0 | 19·0 | 39·0 | 18 | 5·0 | 8 | . . . | . . . | 4·48 | . . . | . . . | 9 | 8 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 1 | 42·3 | 23·0 | 19·3 | 37·0 | 18 | 5·0 | 20 | 81·9 | 29·3 | 3·50 | 4·05 | . . . | 16 | 4 |
| 3 | 45·3 | 25·2 | 20·1 | 33·5 | 18 | 8·0 | 21 | 81·5 | 34·1 | 6·30 | 21·00 | . . . | 13 | 5 |
| 1 | 42·9 | 24·5 | 18·4 | 33·0 | 30 | 6·0 | 22 | 84·7 | 35·4 | 3·32 | 5·25 | . . . | 11 | 6 |
| 2 | 43·2 | 27·4 | 15·8 | 27·6 | 30 | 6·3 | 8 | 75·7 | 27·7 | 5·30 | 15·70 | . . . | 15 | 6 |
| 2 | 42·6 | 27·7 | 14·9 | 34·0 | 30 | 3·0 | 90 | . . . | . . . | 6·54 | 6·50 | ·60 | 12 | 9 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 2 | 45·6 | 26·6 | 19·0 | 30·0 | 14 | 10·0 | 21 | . . . | . . . | 3·67 | 10·00 | . . . | 9 | 12 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 5·20 | 20·00 | . . . | 11 | . . . |
| 2 | 40·1 | 21·2 | 18·9 | 38·5 | 30 | 6·0 | 27 | . . . | . . . | . . . | 22·00 | . . . | . . . | 8 |
| 1 | 41·8 | 24·2 | 17·6 | 30·5 | 18 | 4·4 | 14 | 92·6 | 28·0 | 3·33 | 18·00 | . . . | 15 | 4 |
| 2 | 43·0 | 30·0 | 13·0 | 27·0 | 11 | 1·0 | 27 | 74·5 | 28·5 | 6·60 | 8·00 | . . . | 10 | 13 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 2 | 45·2 | 30·9 | 14·3 | 24·0 | 9 | 6·0 | 20 | 70·0 | 26·0 | 4·42 | 4·70 | . . . | 15 | 7 |
| 2 | 46·1 | 30·8 | 15·3 | 26·0 | 30 | 6·5 | 20 | 78·0 | 30·1 | 5·76 | 5·00 | . . . | 15 | 4 |
| 2 | 41·0 | 25·0 | 16·0 | 29·0 | 30 | 7·0 | 8 | . . . | . . . | 3·80 | 11·00 | . . . | 14 | 14 |
| . . . | 42·2 | 26·2 | 16·0 | . . . | . . . | . . . | . . . | 81·2 | 29·2 | 8·39 | 25·25 | . . . | 12 | 1 |
| 6 | 41·2 | 21·8 | 19·4 | 40·0 | 17 | 8·0 | 15 | 92·1 | 31·1 | 5·17 | 23·00 | . . . | 12 | 3 |
| 2 | 34·8 | 20·7 | 14·1 | 30·0 | 2 | 4·0 | 31 | 72·6 | 20·1 | 5·88 | 14·25 | 3·00 | 11 | 9 |
| 2 | 37·6 | 23·5 | 14·1 | 31·0 | 30 | 4·0 | 12 | 76·4 | 38·2 | 2·72 | 7·50 | . . . | 17 | 3 |
| 2 | 42·9 | 27·2 | 15·7 | 34·0 | 30 | 5·0 | 9 | . . . | . . . | 6·40 | 27·60 | 1·00 | 8 | 10 |
| 2 | 40·6 | 22·0 | 18·6 | 41·0 | 6 | 2·0 | 31 | . . . | . . . | 2·72 | . . . | . . . | 15 | 5 |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| 2 | 38·4 | 22·1 | 16·3 | 34·0 | 2 | 4·0 | 20 | . . . | . . . | 4·19 | 11·00 | 3·00 | 13 | 5 |
| 2 | 40·5 | 24·3 | 16·2 | 32·0 | 11 | 6·0 | 20 | . . . | . . . | 4·32 | 10·50 | 3·50 | 14 | . . . |
| 1 | 44·3 | 24·4 | 19·9 | 37·0 | 30 | 6·0 | 20 | . . . | . . . | 4·50 | 8·50 | . . . | 11 | 13 |
| 2 | 41·2 | 26·5 | 14·7 | 22·0 | 26 | 5·0 | 12 | . . . | . . . | 4·54 | 15·00 | . . . | 14 | 8 |
| 2 | 43·8 | 26·0 | 17·8 | 38·0 | 30 | 7·0 | 8 | 86·4 | 29·6 | 6·07 | 24·00 | 2·00 | 16 | 14 |

## OR MARCH, 1891.

| Number of Days Rainfall. | Number of Days. Clear. | Fair. | Cloudy. | Wind. Prevailing Direction. 7 A. M. | 2 P. M. | 9 P. M. | Observers. |
|---|---|---|---|---|---|---|---|
| 17 | 6 | 7 | 18 | SE | SE | SE | Oscar D. Stewart, Sgt. Sig. Corps. |
| 15 | 7 | 3 | 21 | SW | SW | S | Miss E. A. G. Apple. |
| 16 | . . . | . . . | . . . | . . . | . . . | . . . | Franklin Yager. |
| 16 | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| 19 | 5 | 9 | 17 | SE | SE | SE | A. H. Boyle. |
| 15 | 9 | 6 | 16 | SE | E | E | Prof. J. A. Stewart. |
| 11 | 8 | 6 | 17 | SE | SE | SE | Charles Beecher. |
| 15 | 8 | 8 | 15 | NE | NE | SW | Geo. W. T. Warburton |
| 14 | 14 | 6 | 11 | N | E | W | J. C. Hilsman. |
| 12 | 5 | 12 | 14 | NE | NE | NE | J. L. Heacock. |
| 21 | 7 | 6 | 18 | S | S | S | E. C. Lorentz. |
| 11 | 7 | 8 | 15 | NW | E | E | T. B. Lloyd. |
| 8 | 11 | 5 | 12 | NW | NW | NW | John J. Boyd. |
| 14 | 4 | 12 | 15 | E | E | E | Prof. Wm. Frear. |
| 15 | 11 | 5 | 15 | NW | W | NE | Jesse C. Green, D.D.S. |
| 15 | 9 | 7 | 15 | NE | NE | W | W. T. Gordon. |
| 17 | 9 | 8 | 14 | NE | . . . | NW | Benj. P. Kirk. |
| 14 | 8 | 7 | 16 | NE | . . . | NW | Knowles Croskey. |
| 12 | 9 | 9 | 13 | N | E | NE | Prof. Wm. P. Wickersham. |
| 16 | 5 | 9 | 17 | E | E | E | Rev. W. W. Deatrick, A.M. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | C. M. Thomas, B.S. |
| 14 | 5 | 10 | 16 | E | E | E | Nathan Moore. |
| 16 | 12 | 5 | 14 | E | E | E | Prof. John A. Robb. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| 10 | 3 | 10 | 18 | NW | SE | SE | J. & B. H. Metcalf. |
| 17 | 9 | 7 | 15 | NE | N | W | J. E. Pague. |
| 15 | 11 | 4 | 16 | NE | NE | NE | Frank Ridgway, Sgt. Sig. Corps. |
| 10 | 7 | 11 | 18 | NE | NE | NE | Prof. Susan J. Cunningham. |
| 19 | 5 | 5 | 21 | NE | NE | NE | Peter Wood, Sgt. Sig. Corps. |
| 12 | 8 | 13 | 10 | NW | W | NW | Wm. Hunt. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | Miss Mary A. Ricker. |
| 13 | 9 | 5 | 17 | N | NW | NW | Thomas F. Sloan. |
| 5 | 8 | 10 | 13 | W | W | W | Prof. W. J. Swigart. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | J. E. Rooney. |
| 16 | 4 | 11 | 15 | NE | SE | SW | Prof. S. C. Schmucker. |
| 13 | 5 | 13 | 13 | NE | NW | E | Lewis T. Lampe. |
| 11 | 6 | 7 | 18 | SE | SE | SE | Wm. T. Butz. |
| 15 | 6 | 12 | 13 | NE | NE | NE | Geo. W. Hayes, C.E. |
| 12 | 9 | 5 | 17 | NW | NW | NW | M. H. Boye. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| 9 | 12 | 1 | 18 | NE | NE | NE | A. W Betterly. |
| 11 | . . . | . . | . . . | . . . | . . . | . . . | John S. Gibson, P. M. |
| . . . | 8 | 6 | 17 | S | S | S | Armstrong & Brownell. |
| 15 | 4 | 11 | 16 | N | . . . | S | Prof. S. H. Miller. |
| 10 | 13 | 6 | 12 | W | NW | NW | Charles Moore, D.D.S. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | Lerch & Rice. |
| 15 | 7 | 8 | 16 | NE | NE | NE | Luther M. Dey, Sgt. Sig. Corps. |
| 15 | 4 | 10 | 17 | NE | NE | NE | John Comly. |
| 14 | 14 | 6 | 11 | NE | NE | NE | E. C Wagner. |
| 19 | 1 | 16 | 14 | NW | SW | NW | J. M. Boyer, |
| 12 | 3 | 3 | 25 | NW | NW | NW | W. M. Schrock. |
| 11 | 9 | 7 | 15 | SW | SW | SW | E. S. Chase. |
| 17 | 3 | 11 | 17 | N | N | N | H. D. Deming. |
| 8 | 10 | 6 | 15 | NE | . . . | SW | F. O. Whitman. |
| 15 | 5 | 9 | 17 | E | NE | NE | Wm. Loveland. |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | A. L. Runion, M.D. |
| 13 | 5 | 9 | 17 | NW | NW | NW | Theodore Day. |
| 12 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| 11 | 13 | 3 | 15 | . . . | . . . | . . . | J. T. Ambrose. |
| 14 | 8 | 9 | 14 | NW | NW | NW | Benj. M. Hall. |
| 16 | 14 | 4 | 13 | NE | . . . | NW | Mrs. L. H. Grenewald. |

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

28th, 29th, 30th; Lebanon, 11th; Coopersburg, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 10th, 11th, 14th, 15th, 16th, 17th, 18th, 20th, 26th, 27th; Nisbet, 1st, 2d, 6th, 11th, 30th; Selins Grove, 10th, 11th; Eagles Mere, 6th, 17th; Columbus, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 10th, 11th, 14th, 15th, 16th, 17th, 18th, 19th, 21st, 24th, 25th, 26th, 27th, 28th, 29th, 30th; South Eaton, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 10th, 11th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 26th, 27th; York, 11th.

*Sleet.*—Charlesville, 9th, 20th; Blue Knob, 8th, 9th, 20th, 21st, 22d, 31st; Hollidaysburg, 31st; Quakertown, 20th; Mauch Chunk, 20th; Grampian Hills, 8th; Lock Haven, 20th, 21st; Uniontown, 6th; Coopersburg, 21st; Greenville, 27th; Philadelphia, 20th, 27th; Dyberry, 9th, 20th, 21st; Honesdale, 20th; South Eaton, 20th; York, 13th, 20th.

*Aurora.*—Coopersburg, 26th; Eagles Mere, 16th, 30th; Dyberry, 30th.

*Coronæ.*—Charlesville, 15th, 24th, 25th; Le Roy, 7th; Rimersburg, 25th; Lebanon, 2d, 11th, 15th, 16th, 17th, 18th, 25th, 26th; Dyberry, 18th, 26th.

*Solar Halos.*—Blue Knob, 30th; Le Roy, 2d, 6th, 7th, 11th, 18th, 25th, 26th; State College, 6th; Grampian Hills, 11th; Meadville, 30th; Huntingdon, 1st, 26th, 30th; Lebanon, 2d, 6th, 11th, 26th; Philadelphia, 2d, 6th, 11th, 25th, 26th, 30th; Eagles Mere, 2d, 6th, 11th, 18th, 25th, 26th; Dyberry, 2d, 6th, 18th, 26th; York, 15th.

*Lunar Halos.*—Charlesville, 25th; Hollidaysburg, 15th; Le Roy, 26th; Quakertown, 26th; State College, 15th; Phœnixville, 15th, 26th; Rimersburg, 24th; Meadville, 18th; Huntingdon, 15th; Lancaster, 18th; Lebanon, 18th, 26th; Coopersburg, 26th; Greenville, 17th; Eagles Mere, 18th, 26th; Philadelphia, 15th, 16th; Dyberry, 18th; South Eaton, 18th; York, 15th.

*Polar Bands.*—Le Roy, 17th.

*Parhelias.*—Le Roy, 6th, 11th, 30th; Eagles Mere, 6th; Dyberry, 17th, 27th.

*Zodiacal Lights.*—Le Roy, 10th; Coatesville, 4th, 5th, 10th, 13th.

### WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for March, 1891:

Weather, 90 per cent.

Temperature, 90 per cent.

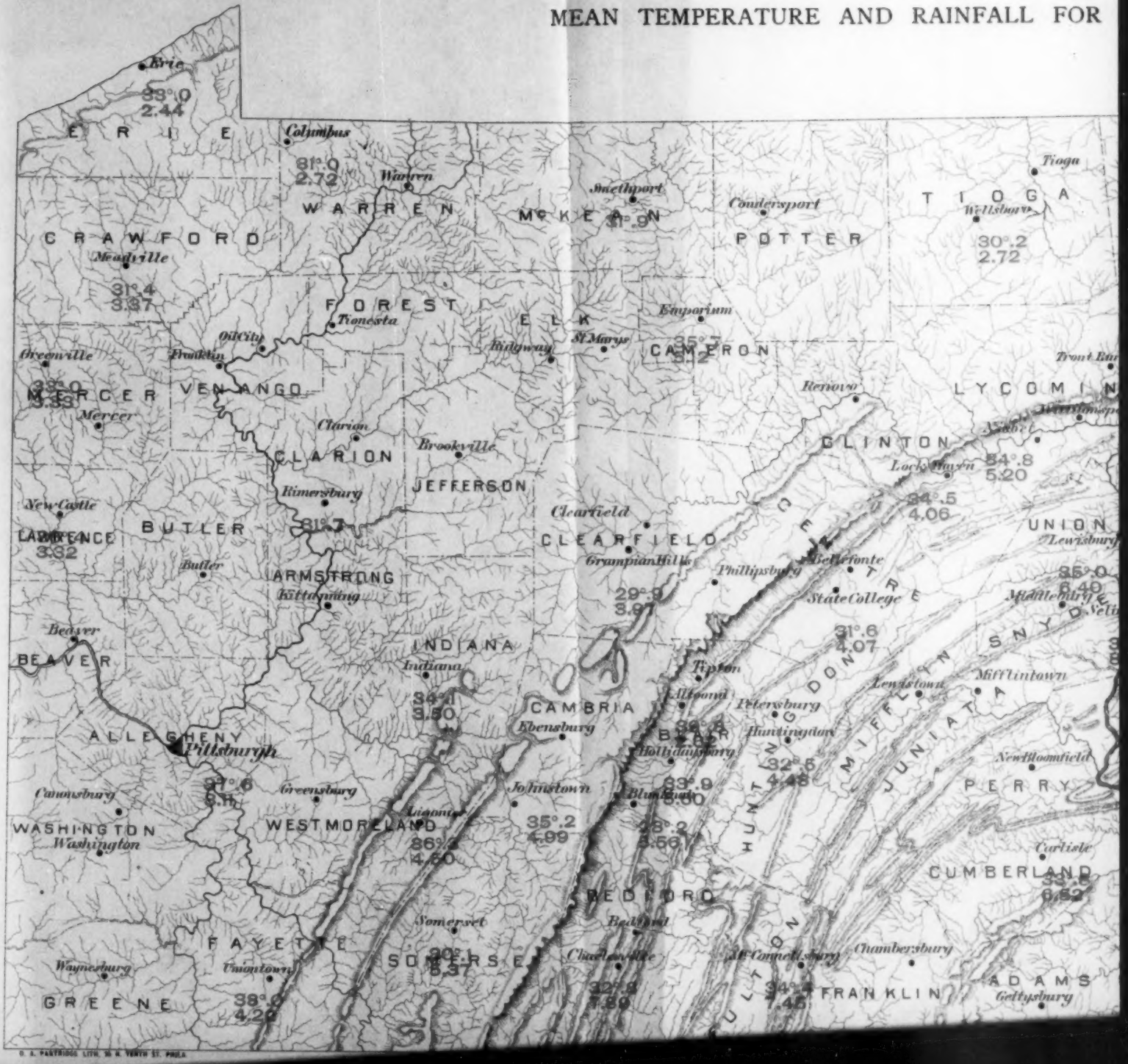
### TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |

| *Displayman.* | *Station.* |
|---|---|
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
| Robt. M. Graham, | Catawissa. |
| Henry F. Bitner, | Millersville. |
| A. M. Wildman, | Langhorne. |
| G. W. Klee, | Chambersburg. |
| A. Simon's Sons, | Lock Haven. |
| *Raftsman's Journal*, | Clearfield. |
| R. C. Schmidt & Co., | Belle Vernon. |
| Chas. B. Lutz, | Bloomsburg. |
| E. C. Lorentz, | Johnstown. |
| W. M. James, | Ashland. |
| Miller & Allison, | Punxsutawney. |
| E. J. Sellers, | Kutztown. |
| H. M. Kaisinger, | Hartsville. |
| Foulk & Co., | Milford. |
| William Lawton, | Wilmington, Del. |
| Wister Heberton & Co., | Germantown. |
| Charles M. Mullen, | Bedford. |
| E. W. Merrill, | North East. |
| A. Simon's Sons, | Lock Haven. |
| Frank Ridgway, | Harrisburg. |

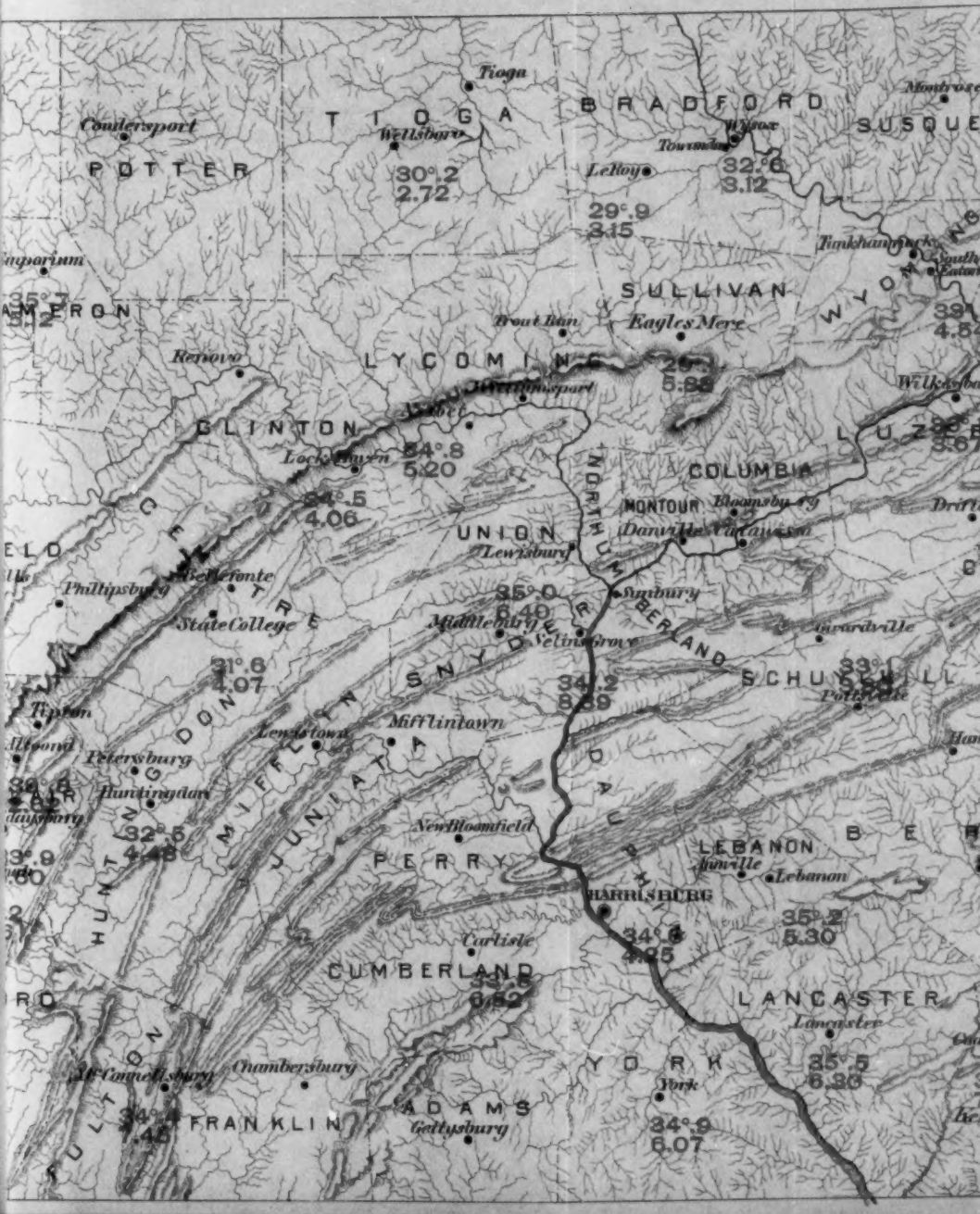
| *Displayman.* | *Station.* |
|---|---|
| G. W. Yost, | Collegeville. |
| A. H. Gerbench, | Annville. |
| Knowles Croskey, | Phoenixville. |
| Powell Bros., | Shadeland. |
| Lincoln E. Rowley, | Athens. |
| P. S. Weber, | Du Bois. |
| E. Jennet, | Franklin. |
| Milton C. Cooper, | Ashbourne. |
| J. L. Long, | Freeport. |
| J. H. Apple, | Clarion. |
| George Wheeler, | Doylestown. |
| J. C. McCloskey, | Lock Haven. |
| Charles Petersen, | Honesdale. |
| Armstrong & Brownell, | Smethport. |
| Frank Loomis, | Troy. |

# MEAN TEMPERATURE AND RAINFALL FOR




C. A. PARTRIDGE, LITH. 30 N. TENTH ST. PHILA.

# EMPERATURE AND RAINFALL FOR MARCH, 1891.



Montrose
USQUEHANNA
WAYNE
Dyberry
30°.7
Honesdale
32°.4
4.32
Scranton
39°.8
4.52
Blooming Grove
Milford
PIKE
Wilkesbarre
3.61
MONROE
Stroudsburg
Drifton
CARBON
Manch Chunk
NORTHAMPTON
Easton
5.69
Lynport
Bethlehem
LEHIGH
Allentown
Hamburg
Kutztown
Womelsdorf
Jonestown
Lebanon
Reading
BUCKS
Doylestown
MONTGOMERY
38°.8
5.35
Pottstown
38°.9
6.60
Norristown
Phoenixville
Hatboro
CHESTER
West Chester
Swarthmore
Media
35°.2
34°.8
7.61
Kennett Square
38°.2
34°.5
8.04
DELAWARE
PHILADELPHIA
38°.0
.42

MAN TEMPERATURE AND RAINFALL FOR

# PENNSYLVANIA STATE WEATHER SERVICE.

## MONTHLY WEATHER REVIEW.

FOR APRIL, 1891.

*Prepared under the Direction of the Committee on Meteorology of the Franklin Institute.*

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 30, 1891.

### TEMPERATURE.

The mean temperature of 50 stations for April, 1891, was 49°·8, which is about 3°·0 above the normal, and 1°·1 above the corresponding month of 1890.

The mean of the daily maxima and minima temperatures 61°·0 and 38°·5 give an average daily range of 22°·5, and a monthly mean of 49°·7.

Highest monthly mean, 54°·2 at Philadelphia, S. O.

Lowest monthly mean, 44°·4 at Dyberry.

Highest temperature recorded during the month, 87°·0 on the 30th at Carlisle, and on the 27th at Lewisburg.

Lowest temperature 11°·4 on the 5th at Greenville.

Greatest local monthly range, 68° at Uniontown and Greenville.

Least local monthly range, 53° at Philadelphia.

Greatest daily range, 55° at Columbus on the 17th.

Least daily range, 1° at Le Roy on the 4th.

From January 1, 1891, to April 30, 1891, the excess in temperature at Philadelphia was 286°, at Erie 347°, and at Pittsburgh 332°.

The warmest days of the month were the 18th, 19th, 20th, 21st, 22d, 27th and 30th. The coldest were the 4th, 5th, 6th, 7th and 8th.

### BAROMETER.

The mean pressure for the month, 30·02, is about ·02 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·54, at Philadelphia, on the 10th, and the lowest, 29·48, at Philadelphia, on the 3d.

### PRECIPITATION.

The average precipitation, 2·08 inches for the month, is a deficiency of about three-quarters of an inch. The largest totals in inches (including melted snow) were Girardville, 3·54; Eagles Mere, 3·15; Philadelphia, 2·82; Quakertown, 2·74, and Johnstown, 2·73.

The least were Wellsboro, 1·12; Somerset, 1·13; Carlisle, 1·18, and Pittsburgh, 1·18.

The largest monthly snowfall totals in inches were Blue Knob, 16; Dyberry, 10; Eagles Mere, 5, and Le Roy, 5.

No snow reported on ground at the end of the month.

### WIND AND WEATHER.

The prevailing wind was from the Northwest. The month was seasonable, with a slight excess of temperature, and a deficiency of rainfall. The prospects for grain, grass and fruit continue favorable.

Average number: Rainy days, 8; clear days, 13; fair days, 9; cloudy days, 8.

### MISCELLANEOUS PHENOMENA.

*Thunder-storms.*—Blue Knob, 14th, 18th, 22d; Hollidaysburg, 22d; Le Roy, 16th, 18th, 22d; Quakertown, 6th, 22d; Johnstown, 18th, 22d; Emporium, 18th, 22d; State College, 18th, 22d; Coatesville, 18th; Kennett Square, 18th; Phœnixville, 16th, 18th; Rimersburg, 14th, 18th, 22d, 30th; Meadville, 11th, 14th, 22d, 30th; Carlisle, 11th, 18th, 22d; Harrisburg, 11th, 18th; Swarthmore, 16th, 18th; Uniontown, 18th; Huntingdon, 18th, 22d; Lancaster, 11th, 18th, 22d; Lebanon, 11th, 14th, 18th, 22d; Coopersburg, 16th, 22d; Wilkes-Barre, 11th, 16th, 22d; Nisbet, 18th, 22d; Smethport, 30th; Pottstown, 16th; Philadelphia, 15th, 16th, 18th, 22d; Girardville, 10th, 12th, 18th, 22d; Selins Grove, 18th, 23d; Eagles Mere, 16th, 18th, 22d; Wellsboro, 18th, 22d; Lewisburg, 18th; Columbus, 22d, 30th; Dyberry, 18th, 22d; Ligonier, 18th; South Eaton, 18th, 22d, 23d; York, 11th, 18th.

*Hail.*—Le Roy, 16th; Johnstown, 22d; Coopersburg, 16th; Greenville, 30th; Philadelphia, 16th; Dyberry, 18th; Honesdale, 18th; South Eaton, 23d; York, 11th.

*Snow.*—Blue Knob, 2d, 3d, 4th, 5th, 6th, 7th, 12th; Hollidaysburg, 2d, 4th; Le Roy, 1st, 2d, 3d; Johnstown, 3d, 4th; Coatesville, 5th, 6th, 7th; Rimersburg, 2d, 3d, 4th; Meadville, 4th; Uniontown, 4th, 5th, 6th, 7th; New Castle, 4th, 6th; Lebanon, 4th; Wilkes-Barre, 2d; Greenville, 4th, 6th; Philadelphia, 6th, 7th; Selins Grove, 4th; Somerset, 2d, 4th; Eagles Mere, 2d, 3d, 7th, 10th; Lewisburg, 3d; Dyberry, 1st, 2d, 3d, 4th, 7th, 10th, 25th.

*Frost.*—Charlesville, 24th, 25th, 28th; Blue Knob, 13th, 17th, 25th, 26th, 29th; Hollidaysburg, 7th, 8th, 9th, 13th, 25th, 26th; Quakertown, 6th, 8th, 9th, 13th, 21st, 25th, 26th; Emporium, 5th, 7th, 8th, 9th, 25th, 26th, 29th; State College, 6th, 7th, 8th, 9th, 13th, 21st; West Chester, 25th; Coatesville, 5th, 6th, 7th, 8th, 9th, 13th, 25th, 26th; Phœnixville, 6th, 7th, 8th, 9th, 25th, 26th; Rimersburg, 13th, 17th, 25th, 26th, 29th; Grampian Hills, 7th, 9th, 13th; Carlisle, 6th, 7th, 9th; Uniontown, 7th, 8th, 9th, 25th, 26th, 29th, 30th; Huntingdon, 24th, 26th; Lancaster, 6th, 8th, 19th; New Castle, 3d, 4th, 5th, 6th, 7th, 8th, 13th, 25th, 26th, 29th; Lebanon, 7th, 8th, 9th; Coopersburg, 5th, 6th, 7th, 8th, 9th; Wilkes-Barre, 5th, 8th, 27th; Nisbet, 8th, 9th, 25th, 26th; Greenville, 7th, 8th, 9th, 13th, 21st, 25th, 26th, 29th; Philadelphia, 5th, 6th, 7th, 8th, 9th; Girardville, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 25th, 26th, 29th; Selins Grove, 6th, 8th, 13th, 24th, 25th; Somerset, 13th, 27th, 28th; Eagles Mere, 8th, 9th, 16th, 17th, 21st, 22d; Wellsboro, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 21st, 25th, 26th, 29th; Columbus, 4th,

| COUNTY. | STATION. | Elevation above Sea Level (feet). | BAROMETER REDUCED TO SEA LEVEL. | | | TEMPERATURE. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | MAXIMUM. | | MINIMUM. | | | | | |
| | | | Mean. | Highest. | Lowest | Mean. | Highest. | Date. | Lowest. | Date. | Mean of Maximum | Mean of Minimum. | Mean. | Greatest |
| Allegheny,[1] | Pittsburgh, | 847 | 30·040 | 30·410 | 29·570 | 53·4 | 81 | 21 | 24 | 5 | 63·2 | 43·7 | 19·5 | 38·0 |
| Bedford, | Charlesville, | 1,300 | . . . | . . . | . . . | 48·8 | 83 | 18 | . . . | . . . | 62·8 | 34·8 | 28·0 | . . . |
| Berks,[1] | Hamburg, | 380 | . . . | . . . | . . . | 51·2 | 84 | 27 | 24 | 6, 8, 9 | 63·4 | 39·1 | 24·3 | 43·0 |
| Berks, | Reading, | 280 | . . . | . . . | . . . | 53·3 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Blair,[2] | Altoona, | 1,181 | . . . | . . . | . . . | 53·8 | 82 | 22 | 27 | 5 | 63·5 | 44·1 | 19·4 | 38·0 |
| Blair, | Blue Knob, | 2,500 | . . . | . . . | . . . | 47·3 | 84 | 18 | 19 | 4 | . . . | . . . | . . . | . . . |
| Blair, | Hollidaysburg, | 947 | . . . | . . . | . . . | 50·4 | 88 | 27 | 21 | 8 | 64·7 | 36·2 | 28·5 | 48·0 |
| Bradford, | Wysox, | 718 | 30·024 | 30·484 | 29·393 | 47·5 | 83 | 22, 27 | 20 | 9 | 59·3 | 34·9 | 24·4 | 48·0 |
| Bradford, | Le Roy, | 1,400 | . . | . . . | . . . | 47·2 | 83 | 27 | 20 | 5, 6 | 56·0 | 37·9 | 18·1 | 35·0 |
| Bucks, | Forks of Neshaminy, | . . . | . . | . . . | . . . | 51·6 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Bucks, | Quakertown, | 536 | 30·030 | 30·520 | 29·500 | 50·4 | 81 | 19 | 21 | 8 | 61·6 | 37·4 | 24·2 | 42·0 |
| Cambria,[1] | Johnstown, | 1,184 | 30·065 | 30·390 | 29·640 | 50·8 | 84 | 27 | 23 | 5, 6 | 62·9 | 38·7 | 24·2 | 46·0 |
| Cameron, | Emporium, | 1,030 | . . . | . . . | . . . | 47·9 | 83 | 22 | 17 | 6 | 61·9 | 33·9 | 28·0 | 46·0 |
| Carbon,[1] | Mauch Chunk (15 days), | 550 | . . | . . | . . | 47·5 | 80 | 19 | 26 | 8 | 56·1 | 38·9 | 17·2 | 31·0 |
| Centre, | State College— Agricultural Experiment Station, | 1,191 | 29·975 | 30·444 | 29·507 | 49·5 | 82 | 22 | 20 | 5, 6 | 59·1 | 38·9 | 20·2 | 33·0 |
| Chester, | West Chester, | 455 | 30·021 | 30·478 | 29·483 | 51·8 | 81 | 19 | 27 | 5, 7 | 61·7 | 42·5 | 19·2 | 32·0 |
| Chester, | Coatesville, | 380 | . . . | . . . | . . . | 51·5 | 84 | 30 | 22 | 9 | 64·0 | 38·3 | 25·7 | 43·0 |
| Chester,[1] | Kennett Square, | 275 | . . . | . . . | . . . | 49·7 | 74 | 19 | 30 | 5 | . . . | . . . | . . . | . . . |
| Chester, | Phœnixville, | 183 | 30·031 | 30·527 | 29·474 | 52·3 | 82 | 19 | 28 | 6 | 62·8 | 41·9 | 20·9 | 41·5 |
| Chester, | Westtown, | 350 | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . |
| Clarion, | Rimersburg, | 1,500 | . . | . . | . . | 48·2 | 80 | 17, 21 | 16 | 5 | 56·7 | 39·9 | 16·8 | 44·0 |
| Clarion, | Clarion— State Normal School, | 1,530 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Clearfield, | Grampian Hills, | 1,450 | . . . | . . . | . . . | 46·9 | 80 | 22, 27 | 14 | 5 | 57·0 | 36·8 | 20·2 | 38·0 |
| Clinton, | Lock Haven, | 560 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Columbia, | Catawissa, | 491 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Crawford, | Meadville, | 1,300 | 30·269 | 30·650 | 29·800 | 47·2 | 76 | 22, 30 | 14 | 5 | 56·9 | 36·6 | 20·3 | 48·0 |
| Cumberland, | Carlisle, | 480 | . . . | . . | . . | 51·4 | 87 | 30 | 24 | 5, 6 | 64·7 | 39·5 | 25·2 | 48·0 |
| Dauphin,[1] | Harrisburg, | 361 | 30·028 | 30·502 | 29·529 | 52·0 | 84 | 30 | 26 | 5 | 62·3 | 43·4 | 18·9 | 34·0 |
| Delaware, | Swarthmore— Swarthmore College, | 190 | 30·012 | 30·482 | 29·526 | 52·2 | 81 | 19 | 25 | 7 | 62·4 | 41·4 | 21·0 | 37·0 |
| Erie,[1] | Erie, | 681 | 30·000 | 30·410 | 29·590 | 47·0 | 78 | 30 | 24 | 6 | 55·0 | 39·0 | 16·0 | 32·0 |
| Fayette, | Uniontown, | 1,000 | 30·003 | 30·472 | 29·570 | 53·1 | 83 | 21 | 15 | 5 | 64·1 | 42·1 | 22·0 | 38·0 |
| Franklin,[1] | Chambersburg— Wilson Female College, | 618 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Fulton, | McConnellsburg, | 875 | . . . | . . . | . . . | 51·7 | 86 | 30 | 24 | 5, 6, 8 | 64·8 | 39·2 | 25·6 | 51·0 |
| Huntingdon,[1] | Huntingdon— The Normal College, | 650 | . . | . . | . . | 50·2 | 86 | 27 | 22 | 6, 7, 8, 9 | 63·5 | 36·9 | 26·6 | 52·0 |
| Indiana, | Indiana— State Normal School, | 1,350 | . . | . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Lancaster, | Lancaster— Franklin and Marshall College, | 411 | 30·068 | 30·465 | 29·576 | 52·9 | 82 | 19 | 24 | 5 | 63·0 | 39·3 | 23·7 | 46·0 |
| Lawrence, | New Castle, | 932 | . . | . . | . . | 52·7 | 82 | 17, 30 | 18 | 5 | 62·0 | 43·4 | 18·6 | 41·0 |
| Lebanon, | Lebanon, | 474 | 30·035 | 30·507 | 29·545 | 52·1 | 84 | 30 | 24 | 9 | 63·7 | 38·1 | 25·6 | 46·4 |
| Lehigh, | Coopersburg, | 520 | . . | . . | . . | 51·7 | 80 | 19, 22 | 25 | 8 | 60·9 | 40·7 | 20·2 | 36·0 |
| Luzerne, | Drifton— Drifton Hospital, | 1,655 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Luzerne,[1] | Wilkes-Barre, | 575 | . . | . . | . . | 51·3 | 84 | 18, 22, 27 | 22 | 8 | 63·9 | 38·7 | 25·2 | 45·0 |
| Lycoming,[1] | Nisbet, | 550 | . . | . . | . . | 49·8 | 80 | 27 | . . | . . | . . | . . | . . | . . |
| McKean, | Smethport, | 1,500 | . . . | . . . | . . . | 46·4 | 80 | 27 | 15 | 6 | 58·6 | 32·7 | 25·9 | 46·5 |
| Mercer,[1] | Greenville— Thiel College, | 1,000 | 29·961 | 30·368 | 29·530 | 47·7 | 79 | 17 | 11 | 5 | 59·2 | 36·3 | 22·9 | 42·5 |
| Montgomery, | Pottstown, | 150 | . . | . . | . . | 53·3 | 83 | 19, 30 | 28 | 6 | 64·3 | 42·4 | 21·9 | 42·0 |
| Northampton, | Bethlehem, | 360 | . . | . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
| Philadelphia,[1] | Philadelphia— Signal Office, | 117 | 30·020 | 30·540 | 29·480 | 54·2 | 83 | 19 | 30 | 5 | 63·4 | 45·2 | 18·2 | 30·0 |
| Philadelphia, | Philadelphia, | 120 | 30·027 | 30·548 | 29·483 | 54·4 | 86 | 19 | 30 | 6 | 64·4 | 44·5 | 19·9 | 34·0 |
| Schuylkill, | Girardville, | 1,000 | 29·982 | 30·407 | 29·534 | 49·9 | 79 | 27, 30 | 23 | 8 | 59·6 | 37·7 | 21·9 | 38·0 |
| Snyder, | Selins Grove, | 445 | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . |
| Somerset, | Somerset, | 2,250 | . . | . . | . . | 46·4 | 84 | 20 | 18 | 5, 6 | 61·2 | 35·9 | 25·3 | 46·0 |
| Sullivan, | Eagles Mere, | 2,000 | 30·086 | 30·514 | 29·583 | 44·6 | 76 | 27 | 16 | 5 | 53·9 | 36·9 | 17·0 | 29·0 |
| Tioga, | Wellsboro, | 1,327 | 29·980 | 30·463 | 29·502 | 45·2 | 82 | 27 | 16 | 8 | 57·3 | 35·2 | 22·1 | 46·0 |
| Union,[1] | Lewisburg, | 450 | . . | . . | . . | 52·0 | 87 | 27 | 25 | 8 | 64·6 | 39·4 | 25·2 | 46·0 |
| Warren, | Columbus, | 1,410 | . . | . . | . . | 45·3 | 84 | 21 | 14 | 6 | 56·7 | 33·8 | 22·9 | 55·0 |
| Washington, | Canonsburg, | 950 | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . | . . |
| Wayne, | Dyberry, | 1,100 | . . | . . | . . | 44·4 | 81 | 18 | 17 | 6, 8 | 56·8 | 33·3 | 23·5 | 44·0 |
| Wayne, | Honesdale, | 1,000 | . . | . . | . . | 46·9 | 80 | 18 | 20 | 5, 8 | 57·4 | 36·0 | 21·4 | 40·0 |
| Westmoreland, | Ligonier (28 days), | 1,250 | . . | . . | . . | 53·2 | 83 | 17, 30 | 16 | 5 | 63·7 | 34·0 | 29·7 | 54·0 |
| Wyoming,[1] | South Eaton | 660 | . . | . . | . . | 48·3 | 81 | 27 | 22 | 8 | 59·1 | 37·5 | 21·6 | 43·0 |
| York,[1] | York, | 385 | 29·994 | 30·428 | 29·545 | 52·5 | 85 | 18, 30 | 22 | 7 | 65·8 | 39·3 | 26·5 | 46·5 |

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

# ORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FO

| | Temperature. | | | | | | | | | Relative Humidity. | Dew Point. | Precipitation. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum. | | Mean of Maximum | Mean of Minimum. | Daily Range. | | | | | | | | | | |
| | Lowest. | Date. | | | Mean. | Greatest. | Date. | Least. | Date. | | | Total Inches. | Total Snowfall During Month. | Depth of Snow on Ground at End of Month. | |
| | 24 | 5 | 63·2 | 43·7 | 19·5 | 38·0 | 17 | 7·0 | 4 | 59·2 | 37·3 | 1·18 | . . . | . . . | |
| | . . . | . . . | 62·8 | 34·8 | 28·0 | . . . | . . . | . . . | . . . | 66·1 | 35·0 | 1·55 | . . . | . . . | |
| | 24 | 6, 8, 9 | 63·4 | 39·1 | 24·3 | 45·0 | 27 | 6·5 | 10 | . . . | . . . | 2·26 | . . . | . . . | |
| | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 1·71 | . . . | . . . | |
| | 27 | 5 | 63·5 | 44·1 | 19·4 | 35·0 | 27 | 6·0 | 2 | 48·3 | 34·0 | 1·36 | . . . | . . . | |
| | 19 | 4 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 1·80 | 16·50 | . . . | |
| | 21 | 8 | 64·7 | 36·2 | 28·5 | 46·0 | 13 | 9·0 | 2 | 66·0 | 39·0 | 1·60 | . . . | . . . | |
| 27 | 20 | 9 | 59·3 | 34·9 | 24·4 | 48·5 | 30 | 4·0 | 4 | 71·5 | 38·5 | 1·79 | 1·00 | . . . | |
| | 20 | 5, 6 | 56·0 | 37·9 | 18·1 | 35·0 | 27 | 1·0 | 4 | . . . | . . . | 2·01 | 5·00 | . . . | |
| | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 1·65 | . . . | . . . | |
| | 21 | 8 | 61·6 | 37·4 | 24·2 | 42·3 | 27 | 7·3 | 10 | 66·2 | 39·3 | 2·74 | . . . | . . . | |
| | 23 | 5, 6 | 62·9 | 38·7 | 24·2 | 46·0 | 30 | 6·0 | 4 | 81·0 | 44·7 | 2·73 | 1·00 | . . . | |
| | 17 | 6 | 61·9 | 33·9 | 28·0 | 46·0 | 27 | 9·0 | 2 | . . . | . . . | 2·33 | . . . | . . . | |
| | 26 | 8 | 56·1 | 38·9 | 17·2 | 31·0 | 14 | 3·0 | 2 | . . . | . . . | ·89 | . . . | . . . | |
| | 20 | 5, 6 | 59·1 | 38·9 | 20·2 | 33·0 | 30 | 6·0 | 3 | 68·6 | 38·2 | 1·47 | ·50 | . . | |
| | 27 | 5, 7 | 61·7 | 42·5 | 19·2 | 38·0 | 30 | 5·0 | 10 | 69·0 | 39·0 | 2·32 | . . . | . . . | |
| | 22 | 9 | 64·0 | 38·3 | 25·7 | 45·0 | 30 | 6·0 | 10 | . . . | . . . | 2·25 | . . . | . . . | |
| | 30 | 5 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·32 | . . . | . . . | |
| | 28 | 6 | 62·8 | 41·9 | 20·9 | 41·5 | 27 | 6·0 | 4 | 74·4 | 47·1 | 2·87 | . . . | . . . | |
| 31 | 16 | 5 | 56·7 | 39·9 | 16·8 | 44·0 | 17 | 4·0 | 3 | . . . | . . . | . . . | . . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 4·00 | . . . | |
| 27 | 14 | 5 | 57·0 | 36·8 | 20·2 | 38·0 | 13 | 4·0 | 2 | . . . | . . . | . . . | . . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·34 | 4·00 | . . . | |
| 30 | 14 | 5 | 56·9 | 36·6 | 20·3 | 48·0 | 17 | 7·0 | 4 | 80·0 | 41·3 | . . . | . . . | . . . | |
| | 24 | 5, 6 | 64·7 | 39·5 | 25·2 | 48·0 | 30 | 3·0 | 2 | 78·7 | 43·2 | 1·53 | 1·50 | . . . | |
| | 26 | 5 | 62·3 | 43·4 | 18·9 | 34·0 | 30 | 4·0 | 10 | 56·5 | 36·3 | 1·18 | . . . | . . . | |
| | 23 | 7 | 62·4 | 41·4 | 21·0 | 37·0 | 27 | 6·9 | 10 | 68·0 | 32·0 | 1·70 | . . . | . . . | |
| | 24 | 6 | 55·0 | 32·0 | 16·0 | 32·0 | 17 | 4·0 | 3 | 77·0 | 39·0 | 1·53 | . . . | . . . | |
| | 13 | 5 | 64·1 | 42·1 | 22·0 | 38·0 | 30 | 6·0 | 2 | . . . | . . . | 1·34 | . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·18 | 3·50 | . . . | |
| | 24 | 5, 6, 8 | 64·8 | 39·2 | 25·6 | 51·0 | 30 | 9·0 | 10 | 67·1 | 39·6 | 2·58 | . . . | . . . | |
| | 22 | 6, 7, 8, 9 | 63·5 | 36·9 | 26·6 | 52·0 | 30 | 8·0 | 2 | . . . | . . . | 1·92 | ·10 | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | |
| | 24 | 5 | 63·0 | 39·3 | 23·7 | 46·0 | 27 | 8·0 | 2 | 72·6 | 45·2 | 1·69 | . . . | . . . | |
| 30 | 18 | 5 | 62·0 | 43·4 | 18·6 | 41·0 | 29 | 9·0 | 4 | . . . | . . . | 2·36 | . . . | . . . | |
| | 24 | 9 | 63·7 | 38·1 | 25·6 | 46·4 | 18 | 7·9 | 2 | 68·1 | 38·4 | 2·19 | ·10 | . . . | |
| 28 | 25 | 8 | 60·9 | 40·7 | 20·2 | 36·0 | 27 | 4·0 | 10 | . . . | . . . | 2·50 | . . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | |
| 27 | 22 | 8 | 63·9 | 38·7 | 25·2 | 45·0 | 30 | 12·0 | 1 | . . . | . . . | . . . | . . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | 2·98 | . . . | . . . | |
| | 15 | 6 | 58·6 | 32·7 | 25·9 | 46·5 | 30 | 5·5 | 4 | . . . | . . . | 2·00 | . . . | . . . | |
| | 11 | 5 | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | |
| 30 | 28 | 6 | 59·2 | 36·3 | 22·9 | 42·5 | 13 | 8·2 | 1 | 84·3 | 40·9 | 1·75 | 2·00 | . . . | |
| . . . | . . . | . . . | 64·3 | 42·4 | 21·9 | 42·0 | 28 | 6·0 | 1 | 72·0 | 44·2 | 1·80 | . . . | . . . | |
| . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | |
| | 30 | 5 | 63·4 | 45·2 | 18·2 | 30·0 | 30 | 5·0 | 4 | 59·0 | 38·0 | 2·34 | . . . | . . . | |
| 30 | 30 | 6 | 64·4 | 44·5 | 19·9 | 34·0 | 30 | 7·5 | 10 | 71·2 | 43·1 | 2·82 | . . . | . . . | |
| | 23 | 8 | 59·6 | 37·7 | 21·9 | 38·0 | 27 | 7·0 | 2 | . . . | . . . | 3·54 | 3·75 | . . . | |
| | 18 | 5, 6 | 61·2 | 35·9 | 25·3 | 46·0 | 20 | 6·0 | 4 | 80·1 | 42·2 | 1·82 | . . . | . . . | |
| | 16 | 5 | 53·9 | 36·9 | 17·0 | 29·0 | 29 | 5·0 | 3 | 67·9 | 35·6 | 1·13 | 3·50 | . . . | |
| | 16 | 8 | 57·3 | 35·2 | 22·1 | 46·0 | 27 | 4·0 | 11 | 77·6 | 30·2 | 3·15 | 5·50 | . . . | |
| | 25 | 8 | 64·6 | 39·4 | 25·2 | 46·0 | 27 | 6·0 | 2 | . . . | . . . | 1·28 | 3·50 | . . . | |
| | 14 | 6 | 56·7 | 33·8 | 22·9 | 55·0 | 17 | 3·0 | 3 | 63·6 | 31·0 | 2·39 | 1·50 | . . . | |
| | 17 | 6, 8 | 56·8 | 33·3 | 23·5 | 44·0 | 30 | 7·0 | 3 | . . . | . . . | 1·80 | . . . | . . . | |
| | 20 | 5, 8 | 57·4 | 36·0 | 21·4 | 40·0 | 30 | 3·0 | 10 | 53·6 | 37·5 | 2·42 | 10·00 | . . . | |
| 30 | 16 | 5 | 63·7 | 34·0 | 29·7 | 54·0 | 30 | 8·0 | 2 | 60·0 | 49·0 | 2·68 | 3·00 | . . . | |
| | 22 | 8 | 59·1 | 37·5 | 21·6 | 43·0 | 27 | 7·0 | 3 | . . . | . . . | 2 23 | ·50 | . . . | |
| 9 | 22 | 7 | 65·8 | 39·3 | 26·5 | 46·5 | 30 | 8·0 | 10 | 71·6 | 41·3 | 2·85 | . . . | . . . | |
| | | | | | | | | | | | | 2·01 | . . . | . . . | |

| IPITATION. | | | NUMBER OF DAYS. | | | WIND. | | | OBSERVERS. |
|---|---|---|---|---|---|---|---|---|---|
| | Depth of Snow on Ground at End of Month. | Number of Days Rainfall. | Clear. | Fair. | Cloudy. | PREVAILING DIRECTION 7 A. M. | 2 P. M. | 9 P. M. | |
| . | . . . | 11 | 12 | 10 | 8 | NW | NW | NW | Oscar D. Stewart, Sgt. Sig. Corps. |
| . | . . . | 5 | 16 | 6 | 8 | S | W | N | Miss E. A. G. Apple. |
| . | . . . | 10 | 7 | 16 | 7 | . . . | . . . | . . . | William Shipe. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Franklin Yager. |
| . | . . . | 7 | . . . | . . . | . . . | . . . | . . . | . . . | Dr. Charles B. Dudley. |
| 0 | . . . | 8 | 13 | 8 | 9 | NW | NW | NW | A. H. Boyle. |
| . | . . . | 8 | 19 | 5 | 6 | W | W | W | Prof. J. A. Stewart. |
| 0 | . . . | 8 | 13 | 4 | 14 | W | W | S | Charles Beecher. |
| 0 | . . . | 9 | 9 | 14 | 7 | SW | SW | SW | Geo. W. T. Warburton |
| . | . . . | 8 | 18 | 7 | 5 | NW | N | W | J. C. Hilsman. |
| . | . . . | 10 | 12 | 11 | 7 | NW | W | NW | J. L. Heacock. |
| 0 | . . . | 10 | 8 | 15 | 7 | SW | . . . | NW | E. C. Lorentz. |
| . | . . . | 8 | 13 | 10 | 8 | W | W | W | T. B. Lloyd. |
| . | . . . | 6 | 10 | 1 | 5 | . . . | . . . | . . . | John J. Boyd. |
| 0 | . . | 10 | 13 | 7 | 10 | W | W | W | Prof. Wm. Frear. |
| . | . . . | 12 | 19 | 4 | 7 | NW | W | W | Jesse C. Green, D.D.S. |
| . | . . . | 9 | 14 | 8 | 8 | W | W | W | W. T. Gordon. |
| . | . . . | 8 | 16 | 7 | 7 | NW | NW | NW | Benj. P. Kirk. |
| . | . . . | 11 | 18 | 5 | 7 | NW | NW | NW | Knowles Croskey. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Prof. Wm. F. Wickersham. |
| 0 | . . . | 11 | 11 | 11 | 8 | W | W | W | Rev. W. W. Deatrick, A.M. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | C. M. Thomas, B.S. |
| 0 | . . . | 9 | 11 | 11 | 8 | W | W | W | Nathan Moore. |
| . | . . | . . | . . . | . . . | . . . | . . . | . . . | . . . | Prof. John A. Robb. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Robert M. Graham. |
| 0 | . . . | 4 | 12 | 10 | 8 | W | W | W | J. & B. H. Metcalf. |
| . | . . . | 8 | 14 | 11 | 5 | W | NW | W | J. E. Pague. |
| . | . . . | 9 | 17 | 5 | 8 | NW | NW | NW | Frank Ridgway, Sgt. Sig. Corps. |
| . | . . . | 6 | 4 | 16 | 10 | W | W | W | Prof. Susan J. Cunningham. |
| . | . . . | 13 | 12 | 8 | 10 | W | W | W | Peter Wood, Sgt. Sig. Corps. |
| 0 | . . . | 8 | 14 | 12 | 4 | NW | NW | NW | Wm. Hunt. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Miss Mary A. Ricker. |
| . | . . . | 3 | 19 | 7 | 4 | E | W | W | Thomas F. Sloan. |
| 0 | . . . | 4 | 19 | 6 | 5 | N | N | N | Prof. W. J. Swigart. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Prof. S C. Schmucker. |
| . | . . . | 9 | 11 | 10 | 9 | W | NW | NW | Lewis T. Lampe. |
| . | . . . | 9 | 11 | 7 | 12 | NW | NW | NW | Wm. T. Butz. |
| 0 | . . . | 9 | 16 | 6 | 8 | SW | SW | NW | Geo. W. Hayes, C.E. |
| . | . . . | 12 | 13 | 9 | 8 | NW | SW | SE | M. H. Boye. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | H. D. Miller, M.D. |
| . | . . . | 8 | 17 | . . . | 13 | NW | NW | NW | A. W Betterly. |
| . | . . . | 7 | 16 | 4 | 10 | W | . . . | E | John S. Gibson, P. M. |
| . | . . . | . . . | 16 | 4 | 10 | W | W | W | Armstrong & Brownell. |
| 0 | . . . | 10 | 11 | 10 | 9 | S | S | S | Prof. S. H. Miller. |
| . | . . . | 3 | 21 | 3 | 6 | W | W | W | Charles Moore, D.D.S. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | Lerch & Rice. |
| . | . . . | 10 | 13 | 8 | 9 | NW | NW | NW | Luther M. Dey, Sgt. Sig. Corps. |
| . | . . . | 11 | 13 | 8 | 9 | NW | NW | NW | John Comly. |
| 75 | . . . | 10 | 19 | 4 | 7 | NW | W | NW | E. C. Wagner. |
| . | . . . | 4 | 3 | 20 | 7 | SW | SW | SW | J. M. Boyer, |
| 30 | . . . | 3 | 8 | 10 | 13 | NW | NW | NW | W. M. Schrock. |
| 10 | . . . | 8 | 13 | 7 | 10 | NW | SW | NW | E. S. Chase. |
| 30 | . . . | 9 | 9 | 11 | 10 | N | N | N | H. D. Deming. |
| 30 | . . | 6 | 15 | 8 | 7 | SW | SW | SW | F. O. Whitman. |
| . | . . . | 13 | 12 | 7 | 11 | N | SW | W | Wm. Loveland. |
| . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | A. L. Runion, M.D. |
| 50 | . . . | 9 | 19 | 10 | 10 | NW | NW | NW | Theodore Day. |
| 00 | . . . | 11 | . . . | . . . | . . . | . . . | . . . | . . . | John Torrey. |
| 50 | . . . | 5 | 18 | 4 | 8 | . . . | . . . | . . . | J. T. Ambrose. |
| . | . . . | 8 | 13 | 9 | 8 | NW | NW | NW | Benj. M. Hall. |
| . | . . . | 8 | 13 | 5 | 13 | NW | NW | NW | Mrs. L. H. Grenewald. |

T. F. TOWNSEND, *Observer, Assistant.*

5th, 6th, 7th, 8th, 9th, 13th, 17th, 25th, 26th, 29th; Dyberry, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 17th, 21st, 25th, 26th, 29th, 30th; Honesdale, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 25th, 26th, 29th, 30th; South Eaton, 1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 25th, 26th, 29th; York, 5th, 6th, 7th, 8th, 9th, 13th, 25th, 26th.

*Sleet.*—Blue Knob, 12th; Uniontown, 3d.

*Aurora.*—Greenville, 8th, 27th, 30th; Eagles Mere, 7th, 8th.

*Coronæ.*—Le Roy, 13th; Quakertown, 13th, 17th; Rimersburg, 13th, 19th; Grampian Hills, 7th; Lebanon, 13th, 15th, 16th, 17th, 19th, 20th, 21st, 22d, 28th; Greenville, 19th, 20th; Philadelphia, 13th, 15th, 17th; Eagles Mere, 13th; Dyberry, 13th, 17th; York, 26th.

*Solar Halos.*—Le Roy, 14th, 29th; Philadelphia, 5th, 6th, 14th, 24th, 29th; Eagles Mere, 9th, 29th.

*Lunar Halos.*—Charlesville, 9th; Hollidaysburg, 17th, 18th; State College, 13th, 16th, 18th, 21st; Phœnixville, 17th, 22d; Meadville, 12th, 19th, 20th; Carlisle, 13th, 14th; Huntingdon, 18th, 20th; Greenville, 18th; Eagles Mere, 22d.

*Meteors.*—Rimersburg, 6th; Greenville, 19th.

*Zodiacal Lights.*—Coatesville, 5th, 6th, 7th, 8th.

### WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for April, 1891:

Weather, 84 per cent.
Temperature, 88 per cent.

### TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

| *Displayman.* | *Station.* |
|---|---|
| U. S. Signal Office, | Philadelphia. |
| Wanamaker & Brown, | " |
| Pennsylvania Railroad Company, | " |
| Continental Brewing Company, | " |
| Samuel Simpson, | " |
| B. T. Babbitt, | " |
| Western Meat Company, | " |
| Neptune Laundry, | " |
| C. W. Burkhart, | Shoemakersville. |
| A. N. Lindenmuth, | Allentown. |
| C. B. Whitehead, | Bradford. |
| Thomas F. Sloan, | McConnellsburg. |
| J. H. Fulmer, | Muncy. |
| W. T. Butz, | New Castle. |
| Capt. A. Goldsmith, | Quakertown. |
| Frank Ross, | Oil City. |
| Lerch & Rice, | Bethlehem. |
| Signal Office, | Erie. |
| J. R. Raynsford, | Montrose. |
| E. P. Wilbur & Co., | South Bethlehem. |

| *Displayman.* | *Station.* |
|---|---|
| Agricultural Experiment Station, | State College. |
| Signal Office, | Pittsburgh. |
| *New Era*, | Lancaster. |
| D. G. Hurley, | Altoona. |
| J. E. Forsythe, | Butler. |
| Steward M. Dreher, | Stroudsburg. |
| State Normal School, | Millersville. |
| E. C. Wagner, | Girardville. |
| L. H. Grenewald, | York. |
| J. E. Pague, | Carlisle. |
| C. L. Peck, | Coudersport. |
| H. D. Miller, | Drifton. |
| M. Tannehill, | Confluence. |
| S. C. Burkholder, | Pollock. |
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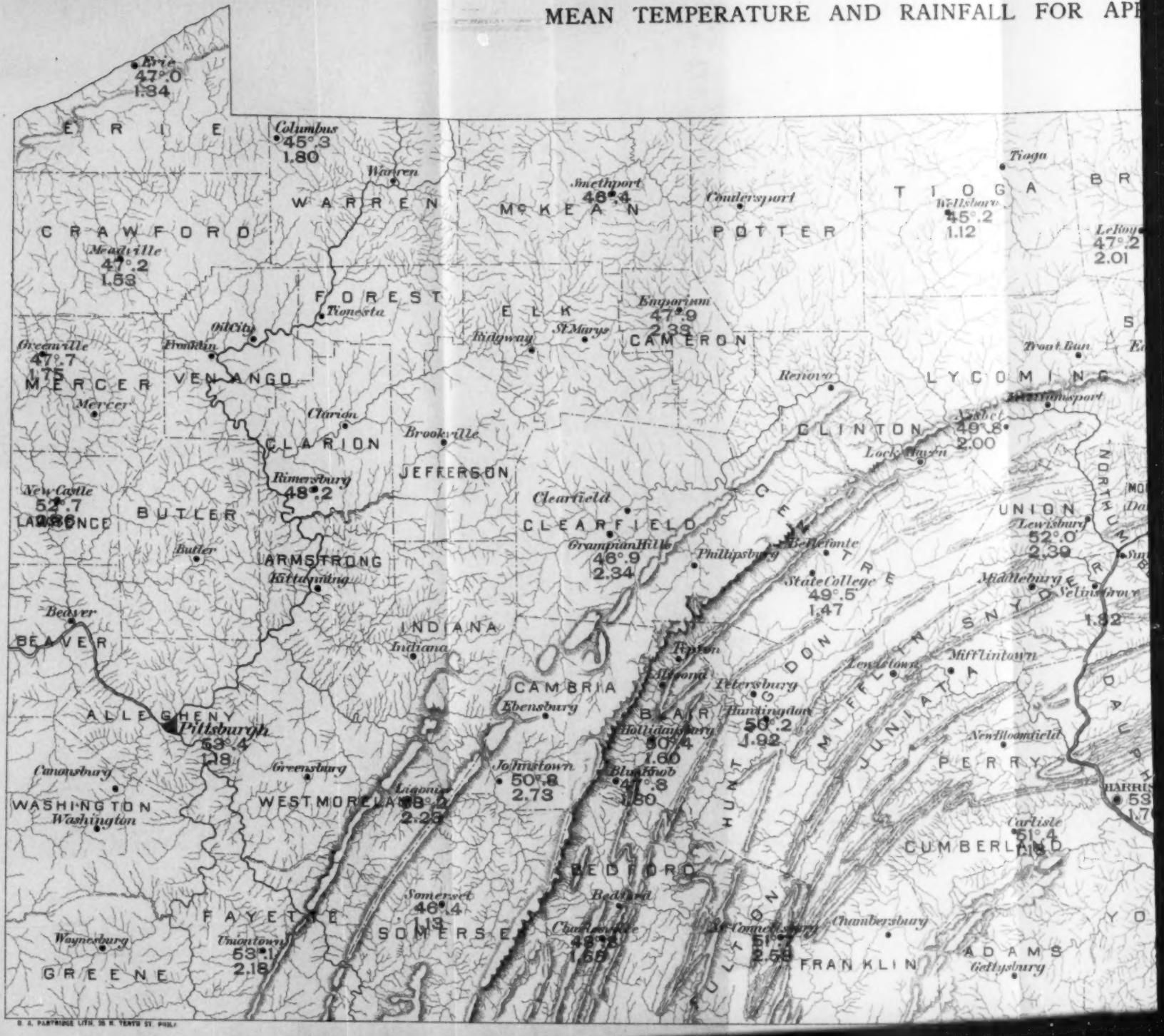


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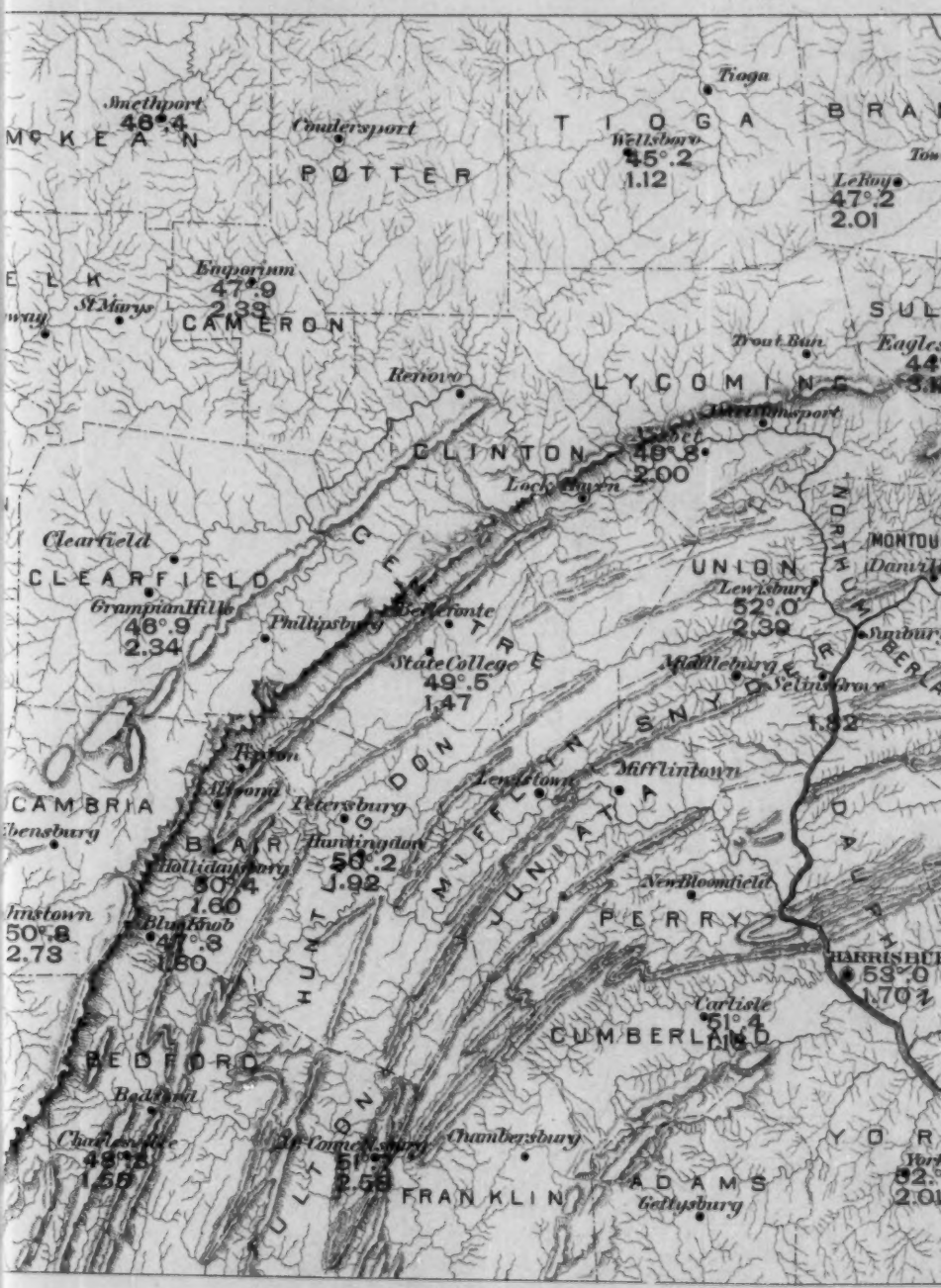

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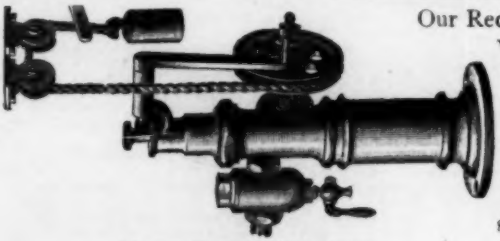

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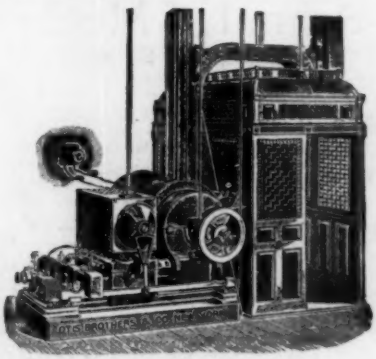

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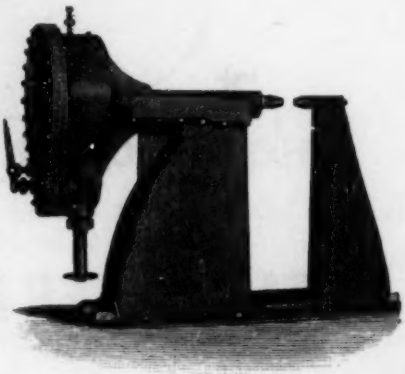

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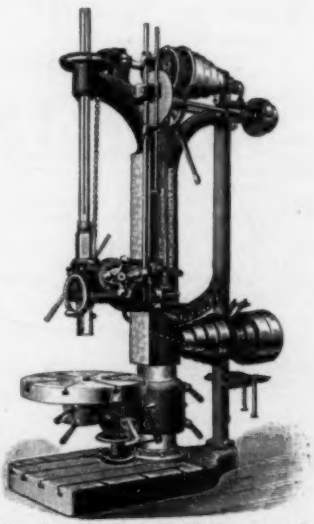

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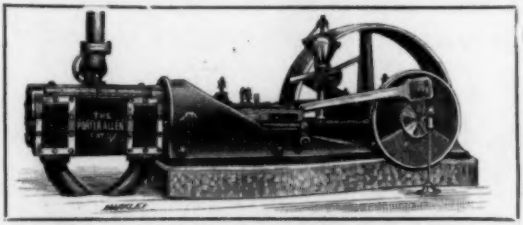

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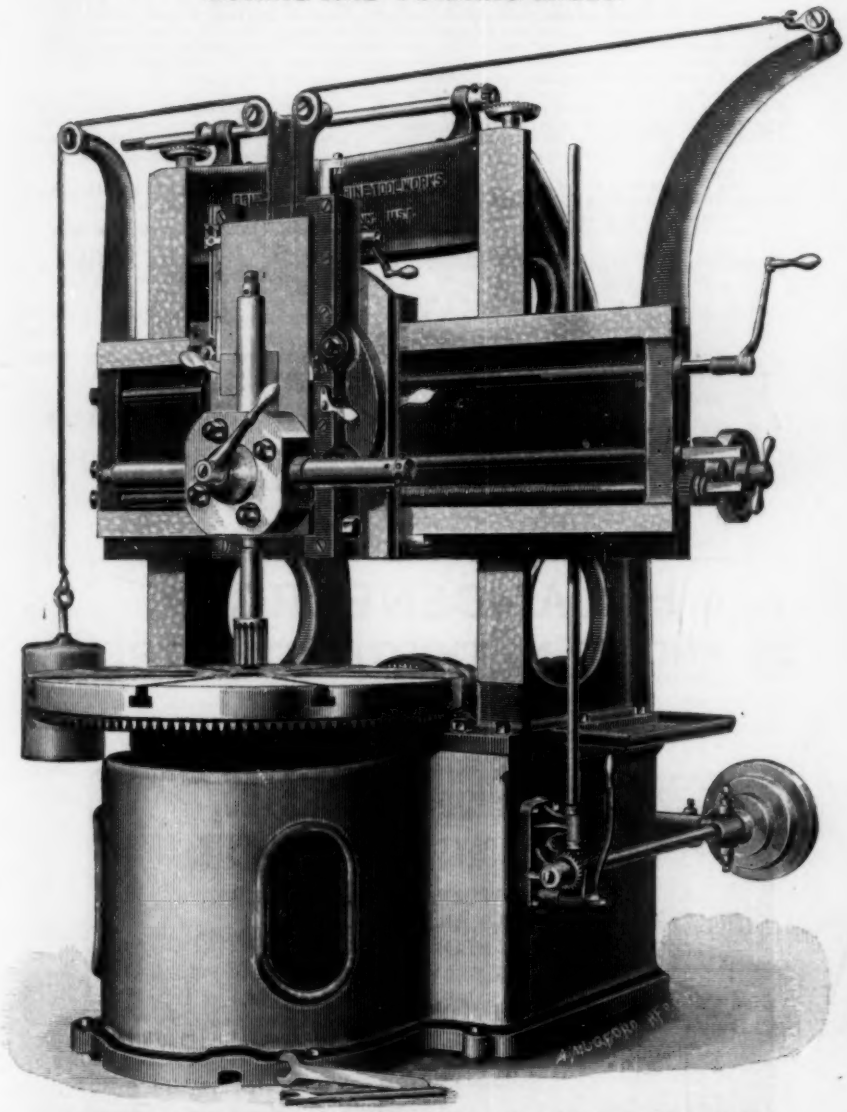

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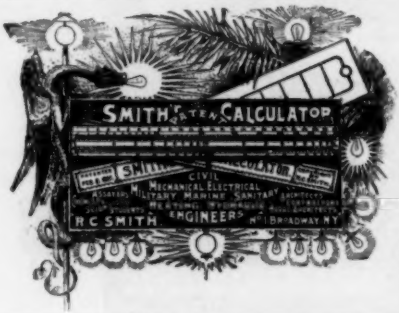


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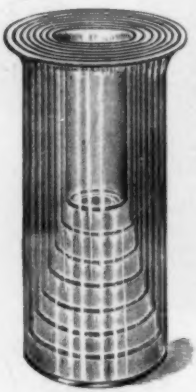

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4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the FRANKLIN INSTITUTE to keep these envelopes securely and unopened until the Judges shall have finished their examination; when should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the INSTITUTE.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the Premium shall become the property of the FRANKLIN INSTITUTE, and shall be published as it may direct.

NOTE.—The sealed envelopes provided for in condition No. 4, which may accompany unsuccessful memoirs, will be destroyed unopened, in the presence of the Board of Managers.

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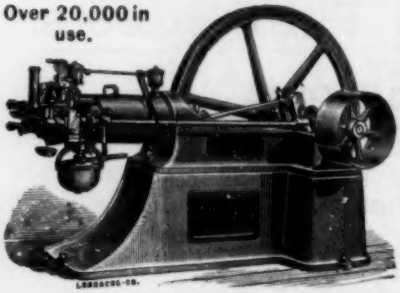

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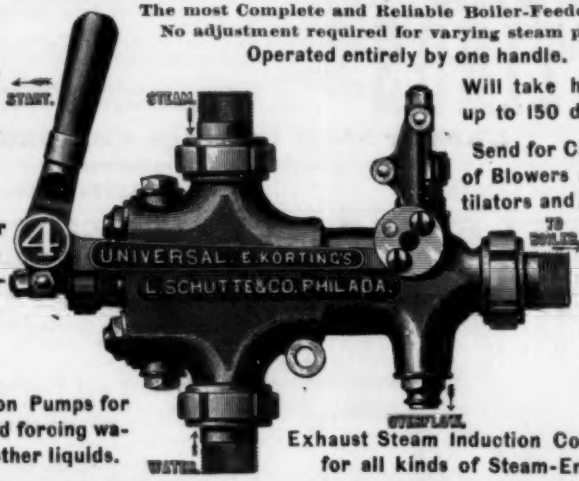


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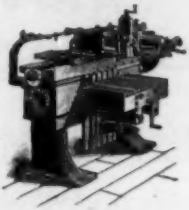

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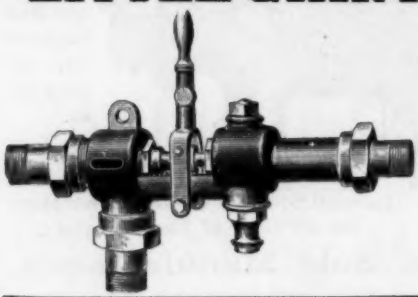

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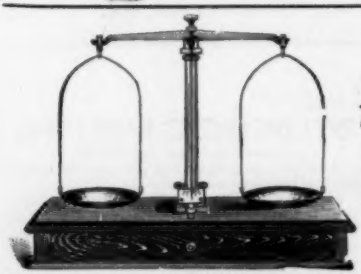

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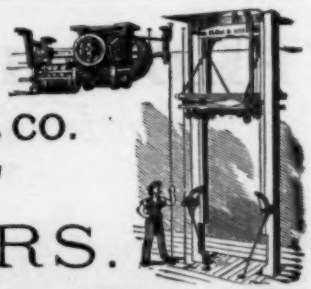

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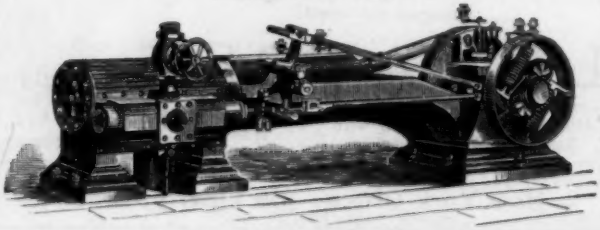

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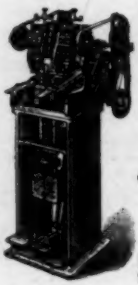

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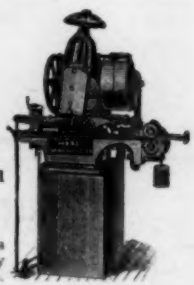

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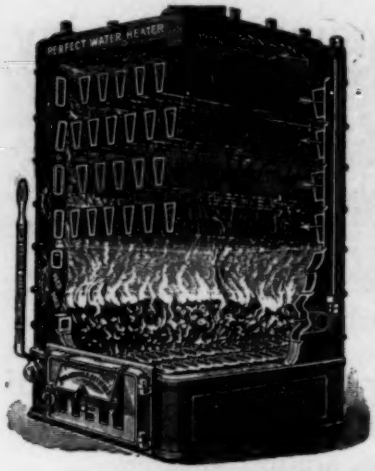


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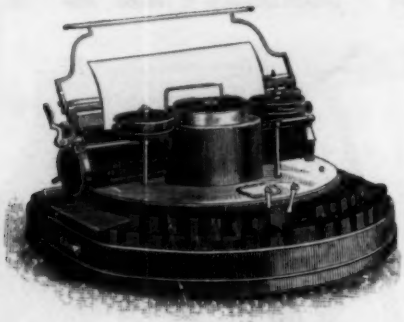

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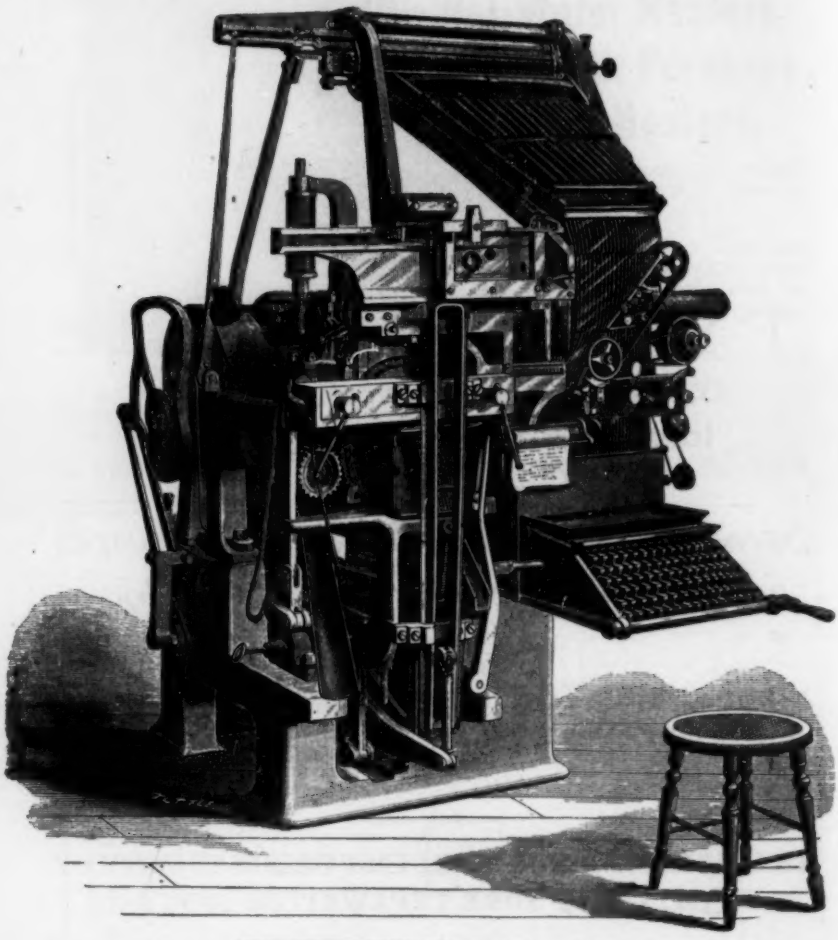

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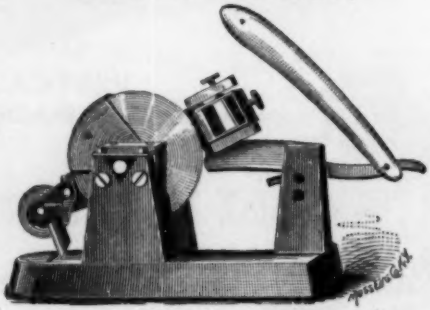

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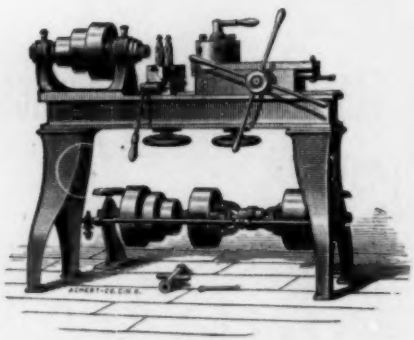

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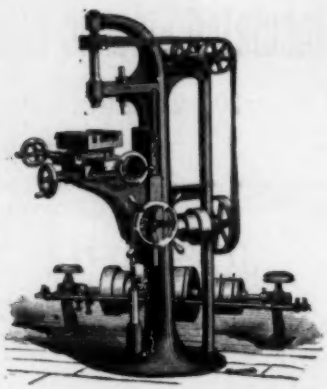

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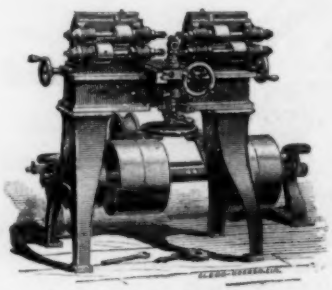

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